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of Engineers**
Waterways Experiment
Station

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October 1993

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Flood Control Channels Research Program

Modified Laursen Method for Estimating Bed-Material Sediment Load

*by Edward B. Madden
Consulting Engineer*

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by **Edward B. Madden**
Consulting Engineer
10109 McCree Road
Dallas, TX 75238

Final report

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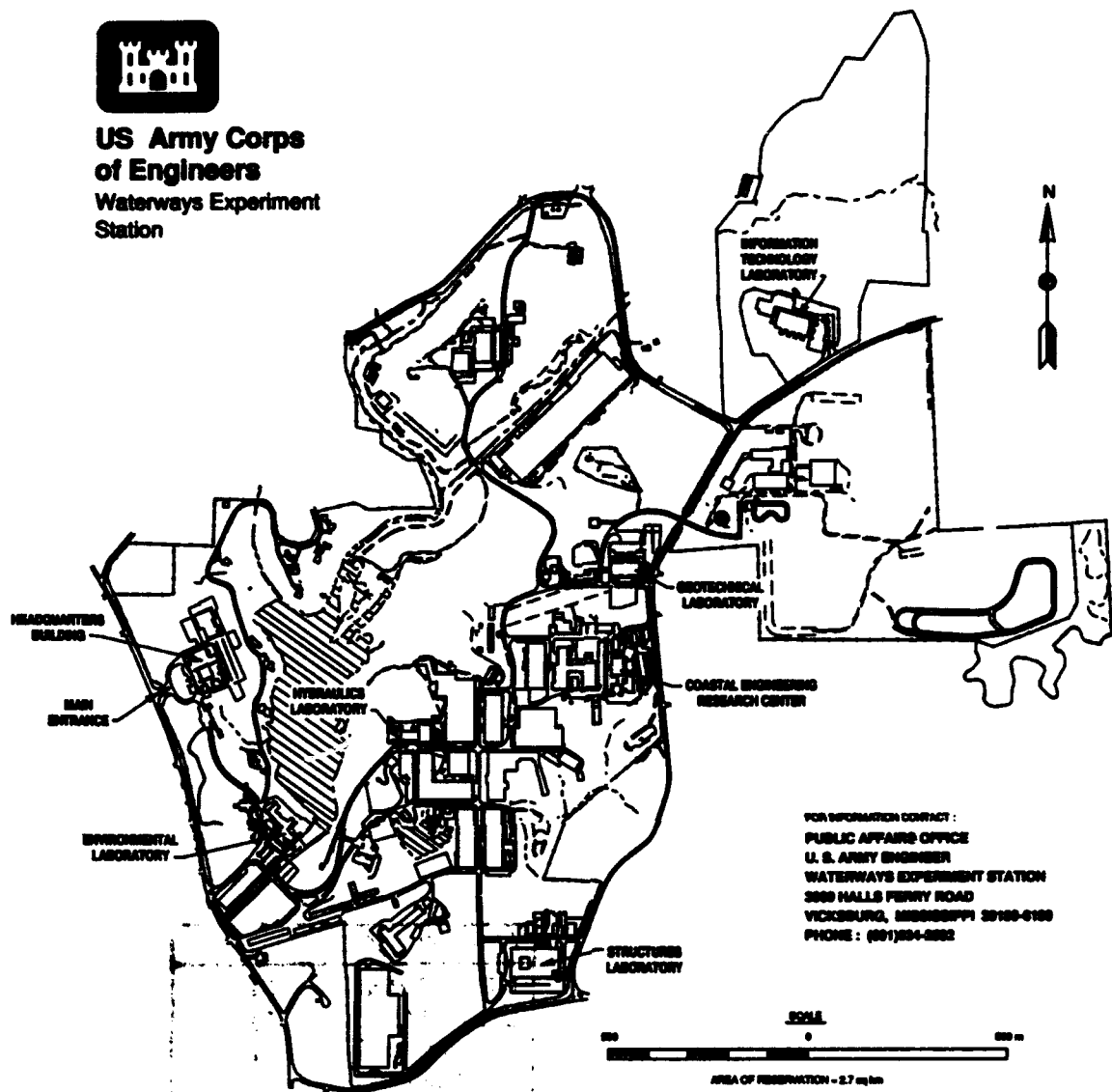
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Preface

The investigation reported herein was conducted for the U.S. Army Engineer Waterways Experiment Station (WES) by Edward B. Madden under Contract DACW39-85-M3699. It documents a modification to coefficients in the Laursen Transport Function using data from streams and rivers. To better fit observations, a new expression involving Froude number of the flow was added to the calculations.

The study, conducted during the period 1984 to 1985, was under the general supervision of Messrs. F. A. Herrmann, Jr., Chief of the Hydraulics Laboratory, WES; R. A. Sager, Assistant Chief of the Hydraulics Laboratory; Mr. M. B. Boyd, Chief of the Waterways Division, Hydraulics Laboratory; and under the direct supervision of Mr. W. A. Thomas, Research Hydraulic Engineer, Waterways Division, who was the Contracting Officer's Representative. This report was prepared by Mr. Madden as part of the contract, and was reviewed by Mr. Thomas.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measure

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
Fahrenheit degrees	5/9	Celsius degrees or kelvins ¹
feet	0.3048	metres
tons (2,000 pounds, mass)	907.1847	kilograms
¹ To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.		

1 Introduction

During planning studies for the Arkansas River navigation channel, which were carried out during the late 1950's and on into 1960, it was considered desirable to express the relation between stream and channel characteristics, discharge, and bed-material sediment load in generalized terms such that the effects of changes in the various parameters involved could be evaluated. A functional relationship developed by Emmett M. Laursen (1968) was used as a framework for developing a generalized working curve for use in the Arkansas River channel design studies. Laursen's relationship was adopted because it is expressed in terms which permit separating readily the effects of the various parameters which are generally considered to govern the relation between the bed-material load, the hydraulic characteristics of the streamflow, and the characteristics of the material of which the streambed is composed. In addition, being empirical, the Laursen relation is susceptible of being adjusted to fit Arkansas River sediment load observations.

2 Laursen Procedure

Using the results of a number of flume tests from various sources Laursen developed a functional relation curve between the expressions $\sqrt{\tau_o/\rho/w}$ and $c/((d/D)^{7/6} ((\tau_o'/\tau_c)-1))$, where $\sqrt{\tau_o/\rho}$ is the shear velocity at the streambed in feet per second, and the second group of parameters is referred to as $f(\sqrt{\tau_o/\rho/w})$; τ_o is the boundary shear or tractive force in pounds per square foot, τ_o' is the boundary shear associated with the sediment particles in the streambed, τ_c is the critical tractive force for beginning of movement of the sediment particles, ρ is the mass density of the fluid (1.94 for water), w is the fall velocity of the sediment particles in water in feet per second, c is the concentration of sediment in percent by weight, d is the diameter of the sediment particle (mean diameter of each fractional size range in feet, D is the depth of flow in feet, and f means "function of."

Laursen's functional relation curve is shown in Figure 1. In attempting to reproduce sediment load versus discharge rating curves which had been developed for gaging stations on the lower Arkansas River from numerous sediment measurements that had been made over a period of many years, it was discovered that the rating curves calculated from Laursen's relation resulted in loads considerably smaller than the curves developed from the long-term measurements. However, the curves did parallel each other. It was also noted that the data point values of $f(\sqrt{\tau_o/\rho/w})$ calculated from Missouri River data by D. C. Bondurant (1968) plotted considerably higher than Laursen's functional relation. For these reasons, a new relationship curve was developed for use in the Arkansas River planning studies, using Laursen's parameters but based on Arkansas River data. Two versions of the modified relationship were developed at different times. Both versions are shown on Figure 1 for comparison with Laursen's original curve.

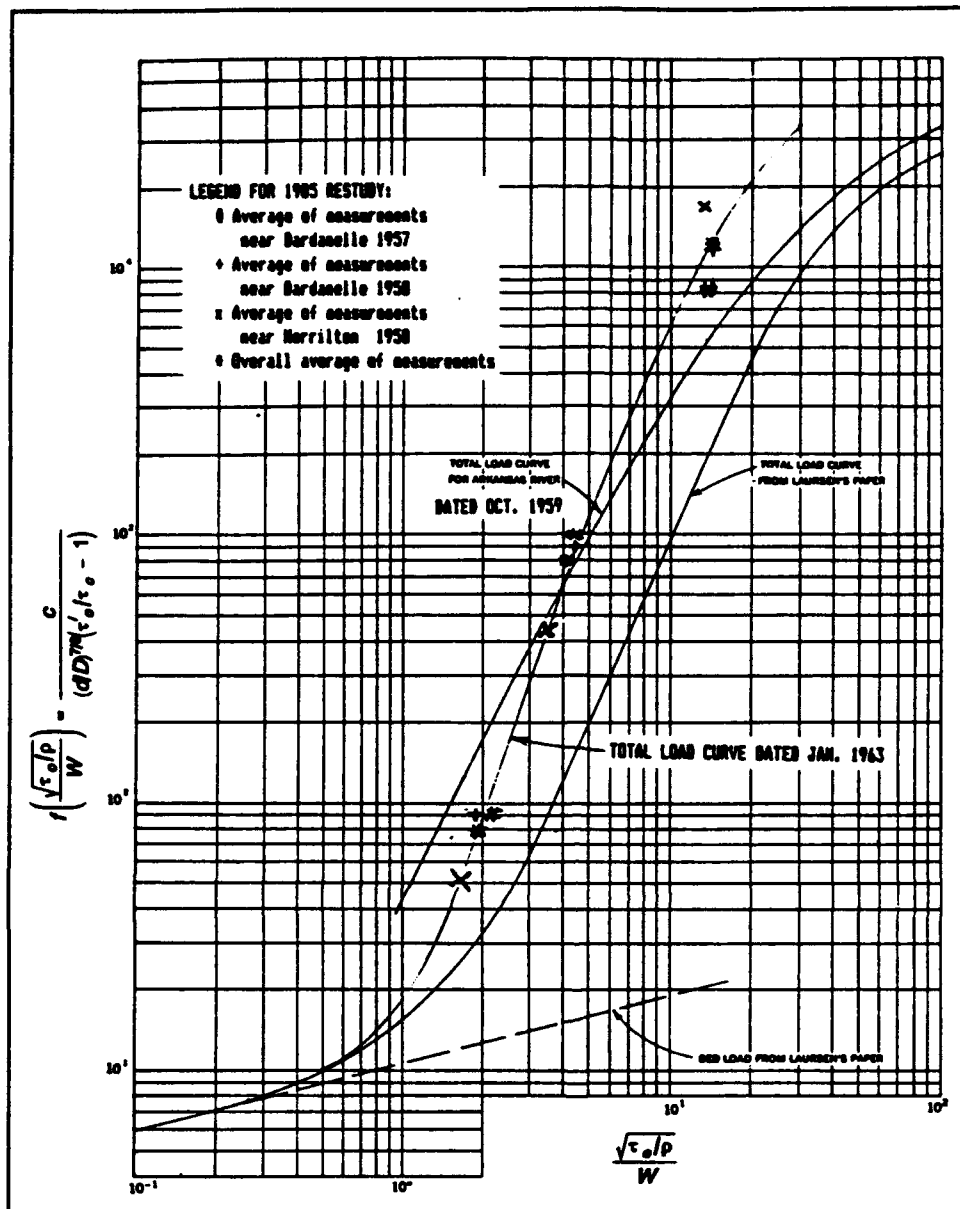


Figure 1. Relation for sediment load, Laursen method

3 Arkansas River Data

Three sets of special measurements were made on the Arkansas River as follows:

Near Dardanelle, Arkansas, in June-July 1957,
Near Dardanelle, Arkansas, in April 1958, and
Near Morrilton, Arkansas, in April 1958.

In each set, the measurements were made on four separate ranges and at five verticals on each range, resulting in 20 measuring locations in each set and a total of 60 locations for the three sets.

The observations at each vertical consisted of the sounded depth, the mean velocity in the vertical, and a depth-integrated suspended sediment sample. Bed-material samples were also obtained at each vertical with a revolving-bucket type sampler during the 1958 measurements at both Dardanelle and Morrilton. Attempts to obtain bed-material samples with a drag-bucket sampler at Dardanelle during the 1957 observations were unsuccessful. The water temperature was measured on each day of the observations. Water surface elevations also were obtained at each range. The total river discharges during the observations were approximately 178,000 cfs¹ at Dardanelle in 1957, 121,000 cfs at Dardanelle in 1958, and 97,000 cfs at Morrilton in 1958.

¹ A table of factors for converting non-SI units of measure to SI units is found on page v.

4 Development of Modified Laursen Functional Relationship

The sediment size classification used in this study is presented in the following tabulation:

Sediment-size Class	Size Range in mm	Geometric Mean for in mm	Size Class in feet
Coarse Silt	0.031 - 0.0625	0.044	0.000142
Very Fine Sand	0.0625 - 0.125	0.088	0.000285
Fine Sand	0.125 - 0.250	0.177	0.000580
Medium Sand	0.250 - 0.500	0.353	0.001158
Coarse Sand	0.500 - 1.00	0.707	0.00232
Very Coarse Sand	1.00 - 2.00	1.414	0.00464
Very Fine Gravel	2.00 - 4.00	2.828	0.00928

Sediment fall velocities as a function of grain size and water temperature are shown in Figure 2.

The procedure for developing the desired functional relationship consists essentially of calculating values of $\sqrt{\tau_o/\rho/w}$, $(d/D)^{7/6}$, and $((\tau_o'/\tau_o)-1)$ for each data point, based on the observed information on flow and bed-material characteristics and then solving for $f(\sqrt{\tau_o/\rho/w})$ using the equation:

$$f(\sqrt{\tau_o/\rho/w}) = (c/P_s) / \left\{ P_b(d/D)^{7/6} [(\tau_o'/\tau_o)-1] \right\} \quad (1)$$

where P_s is the fraction of suspended material of the size class represented by d , P_b is the fraction of bed material of the size class represented by d , and the other symbols are as previously defined.

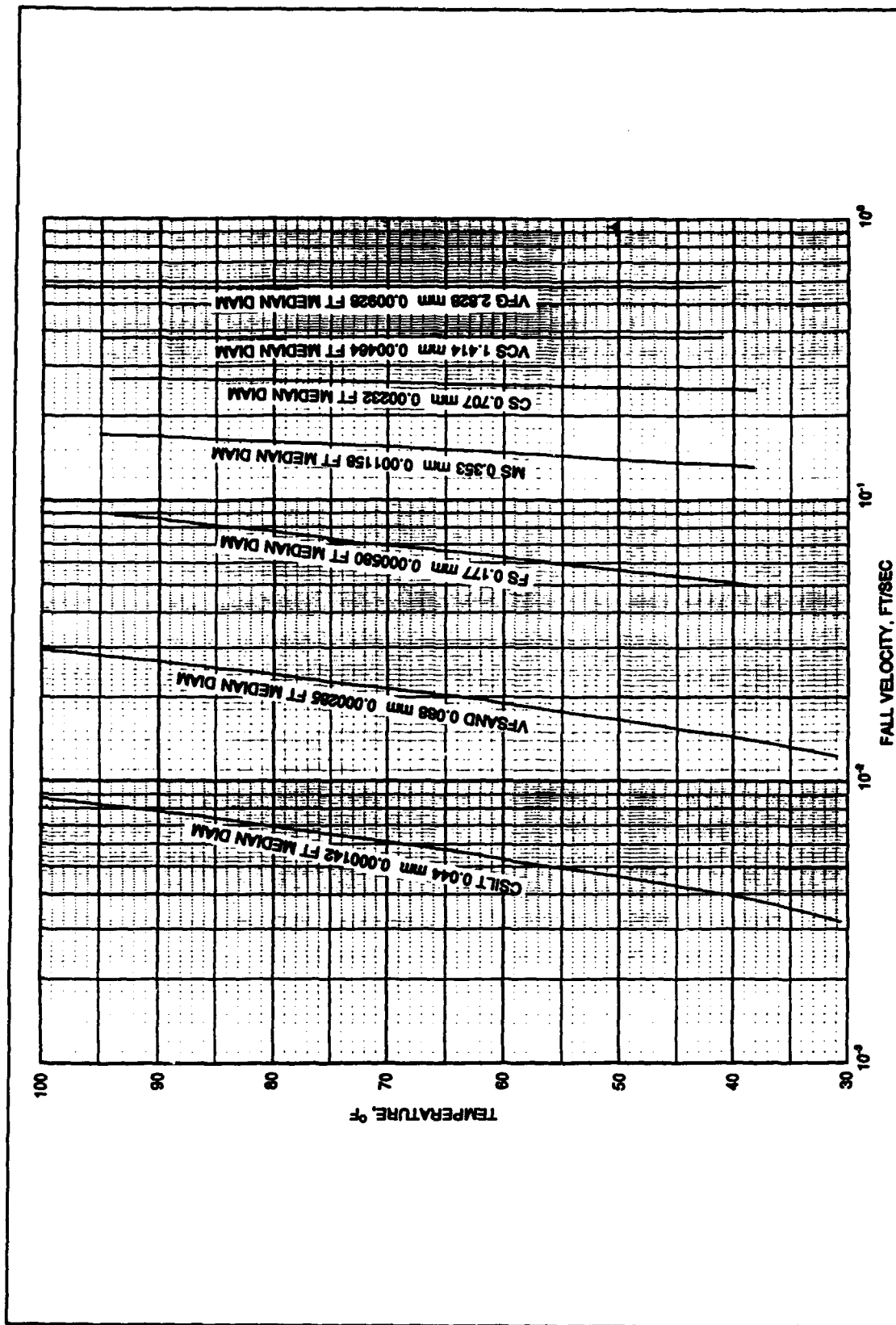


Figure 2. Sediment fall velocity

Additional pertinent equations are as follows:

$$\tau_o = \gamma DS = 28.25n^2 V^2 / D^{1/3} \quad (2)$$

$$\tau_o' = (V^2 / 30d_m / D)^{1/3} \quad (3)$$

$$\tau_c = 4d \quad \text{in general,} \quad (4a)$$

$$\text{but } \tau_c > 4d \text{ for particles less than .088mm in size} \quad (4b)$$

$$q_s = 27qc \quad \text{or } Q_s = 27Qc \quad (5)$$

In these equations γ is the specific weight of the fluid in pounds per cubic foot (62.4 for water), S is the energy gradient in feet per foot, n is the Manning roughness coefficient, V is the mean velocity in feet per second, d_m is the median size of the sediment mixture in the streambed in feet (considered representation of the grain roughness of the bed), q is the discharge per foot width in cubic feet per second per foot, Q is the total discharge in the stream cross section in cubic feet per second, q_s is the sediment load in tons per day per foot width, and Q_s is the total sediment load in the channel cross section in tons per day. These and other symbols are summarized in a list of symbols, Appendix A.

The procedure described above was applied to each sediment size class in the suspended and bed material samples at each observation location. These calculations resulted in values of $f(\sqrt{\tau_o/\rho/w})$ for the suspended sediment corresponding to each value of $(\sqrt{\tau_o/\rho/w})$. Values of $f(\sqrt{\tau_o/\rho/w})$ for bed load were calculated from the equation.

$$f(\sqrt{\tau_o/\rho/w})_b = 10.7378 (\sqrt{\tau_o/\rho/w})^{0.25301} \quad (6)$$

which was deduced from Laursen's curve labelled "Bed load" in Figure 1. The bed-load values were added to the suspended-load values to obtain values of $f(\sqrt{\tau_o/\rho/w})$ applicable to the total load. Plotting of the resulting values of $f(\sqrt{\tau_o/\rho/w})$ versus corresponding values of $\sqrt{\tau_o/\rho/w}$ served as the basis for developing the functional relationship curve. As the many points were widely scattered, group averaging was employed to aid in plotting the curve. The points fell into groups according to sediment-size class. Accordingly, the group averaging was performed on a size-class basis.

The latest, 1985, implementation of the procedure described above is illustrated in detail by Table 1. In the interest of simplifying computer print-outs, the symbols To , To' , X , Y , and Y' have been substituted for τ_o , τ_o' , $\sqrt{\tau_o/\rho/w}$, $f(\sqrt{\tau_o/\rho/w})$ for suspended load, and $f(\sqrt{\tau_o/\rho/w})$ for total load, respectively. The results of computations for all of the special Arkansas River observations at Dardanelle and Morrilton in 1957 and 1958 are included in Appendix B of this report as Tables B-1 through B-12. The computation of group averages of data points is included as Table B-13.

At the time of the Arkansas River project planning studies, the results of laboratory analyses of the bed-sediment samples had not been completed. Because of this, it was necessary to use the results of bed-material samples obtained previously during relatively low river flows. The resulting modified functional relationship curve in Figure 1 is labelled "Curve dated October 1959." The application of that relationship curve to the Arkansas River project planning studies is described in Madden (1964).

The relationship curve was revised in 1963 utilizing the results of the bed-material samples that were obtained at the time of the special observations in 1958. The 1958 samples at Dardanelle were assumed to be applicable to the 1957 observations at Dardanelle in the absence of actual bed-samples at that time. The 1963 modified relationship curve is labelled "Curve dated Jan. 1963" in Figure 1. A more detailed "working-curve" version of the 1963 curve is included as Figure 3 of this report. Copies of this curve were distributed to attendees at a course in Sediment Problems in Hydraulic Engineering that was held at the US Army Engineer Waterways Experiment Station in Vicksburg, MS, May 18-22, 1970.

The group-averaged data points computed in the latest (1985) study agree very closely with the 1963 relationship curve. Consequently, further revision of that curve is considered not warranted.

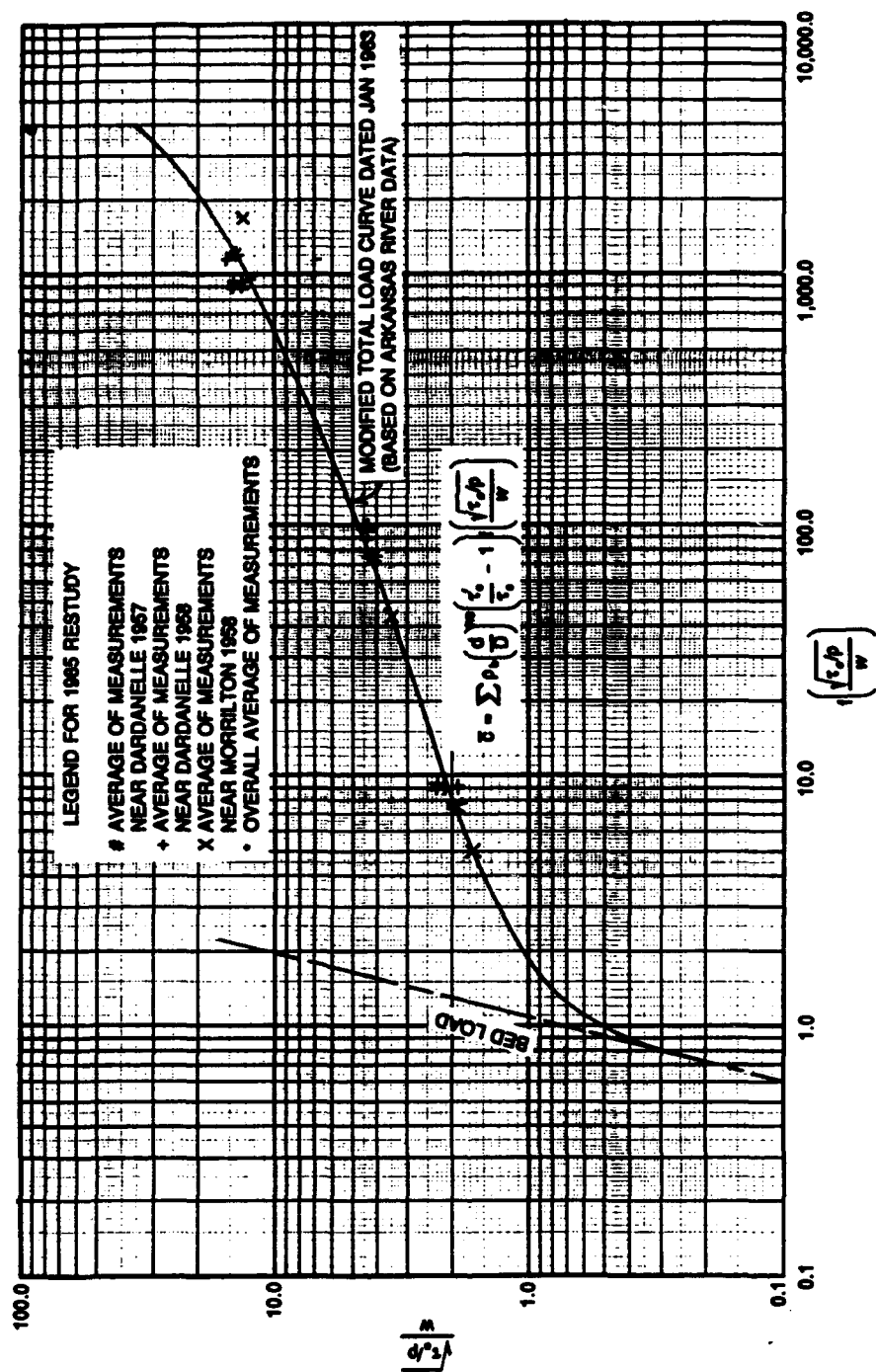


Figure 3. Modified relationship for sediment load, working curve

5 Application of Modified Laursen Functional Relationship

Calculation of the bed-material sediment concentration follows a reverse process to that described above. Data requirements include the flow depth or hydraulic radius, D or R ; the velocity, V ; the energy gradient, S ; or a Manning n value; a grain-size distribution for the bed material, P_b ; and an observed or estimated water temperature, TDF . The parameters $\sqrt{\tau_o/\rho/w}$, $(d/D)^{7/6}$, and $((\tau_o'/\tau_c)-1)$ are first computed from the known information as before. For each value of $\sqrt{\tau_o/\rho/w}$, a corresponding value of $f(\sqrt{\tau_o/\rho/w})$ is then read from the functional relationship curve. The sediment concentration is then calculated by means of the equation:

$$c = P_b(d/D)^{7/6} ((\tau_o'/\tau_c)-1)f(\sqrt{\tau_o/\rho/w}) \quad (7)$$

The sediment load is calculated from Equation 5.

The calculations are carried out for each grain-size class, and the resulting incremental loads are then summed to obtain the combined load for all sizes. For total load, Equation 7 is modified as follows:

$$\bar{C} = \sum P_b(d/D)^{7/6} ((\tau_o'/\tau_c)-1)f(\sqrt{\tau_o/\rho/w}) \quad (7a)$$

where \bar{C} is the total bed-material concentration and \sum represents summation.

As a test of the procedure, it has been applied to the following locations at which observed sediment concentration data are available for comparison with computed values:

RIVERS:

Atchafalaya River at Simmesport, Louisiana

Mississippi River at Tarbert Landing, Louisiana

Mississippi River at St. Louis, Missouri
 Red River at Alexandria, Louisiana
 Rio Grande near Bernalillo, New Mexico
 Middle Loup River at Dunning, Nebraska
 Niobrara River near Cody, Nebraska
 Arkansas River at Dardanelle and Morrilton, Arkansas

FLUME TESTS:

Simons and Richardson, 0.19mm sand, Colorado State University

" " " 0.27mm sand " " "

" " " 0.45mm sand " " "

" " " 0.93mm sand " " "

Toch, 0.04mm sand, Iowa Institute of
 Hydraulic Research

The information on all of the rivers except the Arkansas was obtained from a paper by Toffaleti (1968). Information on the flume tests by Simons and Richardson was obtained from Guy, Simons, and Richardson (1966). Information on the flume tests by Toch was obtained from Laursen (1968).

Calculation of the bed-material sediment load is demonstrated in detail in Table 2. Calculations for all of the locations listed above are included in Appendix C as Tables Nos. C-1 through C-27. Critical tractive force values of $4d$ were assumed for all computations except for the Toch flume tests, for which a value of $5d$ was used because of the small size of the bed material. The tables include computations of ratios of computed load to observed load. A wide variation in the ratios can be noted. In an investigation to determine whether or not some additional parameters should be included in the procedure, the ratios were plotted against values of the Froude number, $F_r = V/\sqrt{gD}$, where g is the gravitational acceleration. The Froude number is considered to be one of the factors governing the presence of ripples, dunes, antidunes, plane bed, or intermediate transitions. (See Albertson, Simons, and Richardson (1958) and a relationship of dune wave steepness versus Froude number presented in Vanoni (1975) from a study by Kennedy (1963).) Variations in these bed-regime features affect the bed roughness and turbulence, which, in turn, affect the flow-sediment interaction.

The plot of the computed-to-observed load ratios versus Froude numbers on log-log graph paper is shown in Figure 4. A definite correlation can be observed. A representative straight-line curve has been drawn in an approximately median position among the points. Most of the points lie within enveloping curves drawn at positions giving ratio values from one-half to two times the median curve values. This degree of correlation is considered good for field sediment data. Almost all of the points are within a range of one-third to 3 times the median values. This is considered acceptable.

Two of the points diverge widely from the others. An examination of the basic information on these points revealed that sediment transport was very small, consisting entirely or almost entirely of bed-load movement with little

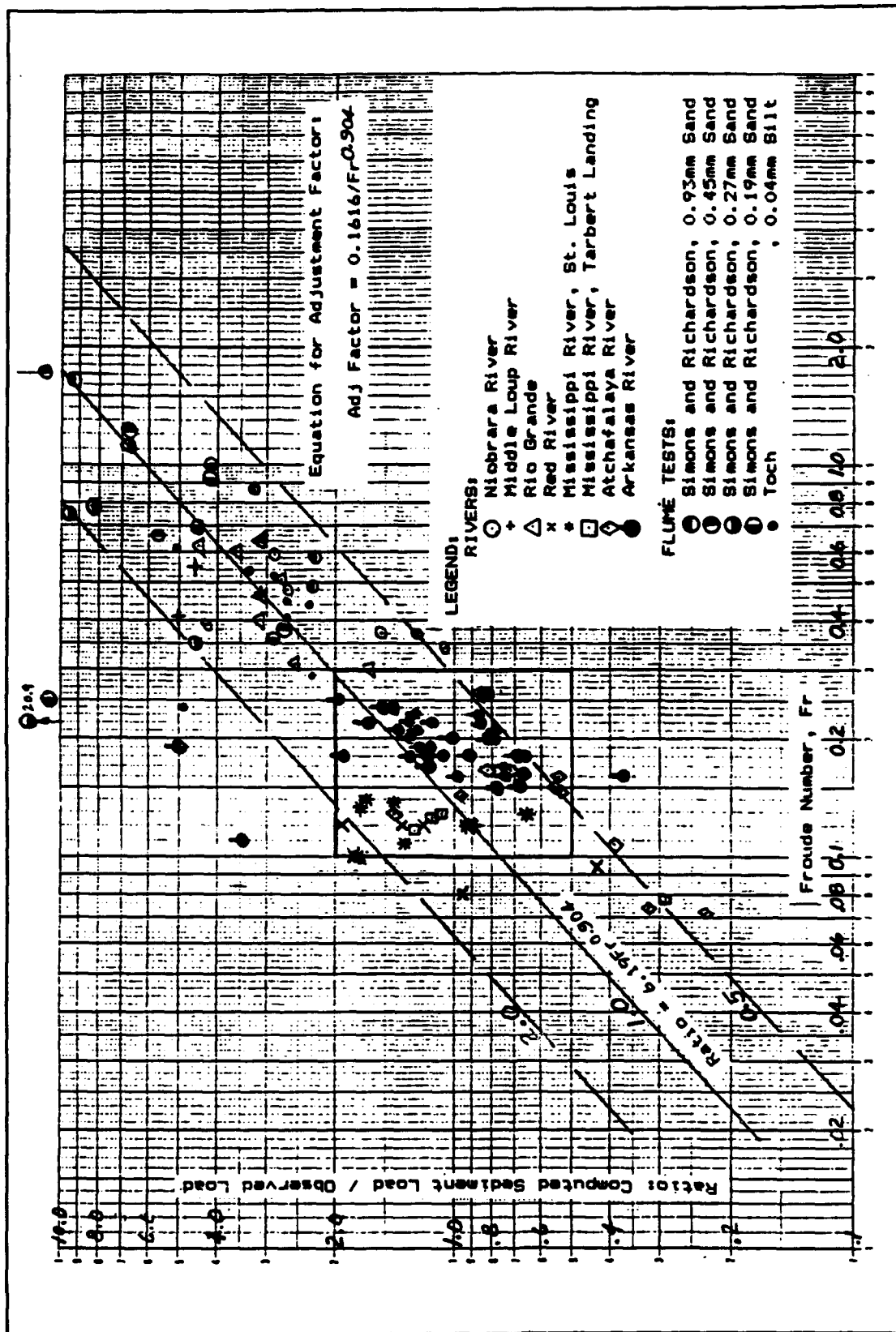


Figure 4. Modified Laursen method, error analysis

or no suspended load. The bed configuration was in the ripple regime. Also, it was noted that the grain-associated tractive force, τ'_o , for the median-size was only 1.4 and 1.5 times the computed critical tractive force, τ_c . This suggests the possibility of a "hiding effect," in which the smaller particles are partially sheltered when movement of the median size is marginal, or that the assumed value of $4d$ does not define the critical tractive force with sufficient accuracy under near-threshold conditions.

The following equation was deduced for the median curve of relationship between the ratio of computed to observed sediment load and the Froude number:

$$\text{Ratio} = 6.19F_r^{0.904} \quad (8)$$

An adjustment factor for adjustment of the computed load can be computed from the inverse of the latter equation:

$$\text{Adj. Factor} = 0.1616/F_r^{0.904} \quad (9)$$

Equation 9 was applied to each initially computed load or concentration in Tables 2 and B-1 through B-27 to obtain adjusted values of computed load or concentration. Although the adjustment was performed as a separate operation in the tables for illustrative purposes, it should be noted that Equation 9 can be incorporated into Equations 7 and 7a, resulting in the equations:

$$c = P_b(d/D)^{7/6} ((\tau'_o/\tau_c)-1)f(\sqrt{\tau_o/\rho}/w)(0.1616/F_r^{0.904}) \quad (10)$$

$$\text{and } \bar{C} = \Sigma P_b(d/D)^{7/6} ((\tau'_o/\tau_c)-1)f(\sqrt{\tau_o/\rho}/w)(0.1616/F_r^{0.904}) \quad (10a)$$

As indicated previously, the bed-material load is computed by means of the equation:

$$q_s = 27q\bar{C} \quad \text{or} \quad Q_s = 27Q\bar{C} \quad (11)$$

A plot of all values of adjusted computed loads or concentrations versus observed loads or concentrations, shown in Figure 5, indicates acceptable results, comparable to results of other sediment load computation procedures.

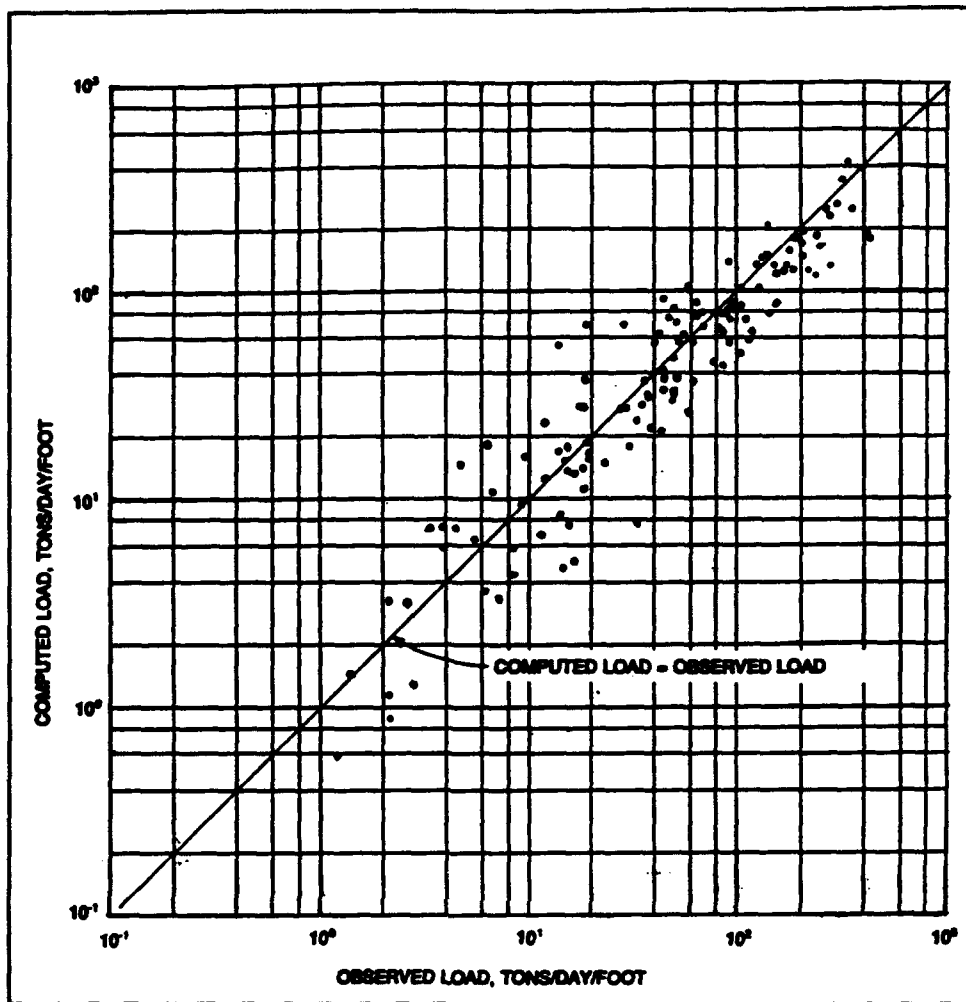


Figure 5. Comparison of results

6 Range of Applicability

The modified Laursen procedure has been applied to sediments ranging in size from coarse silt (noncohesive) to very fine gravel, flow depths ranging from 0.25 to 54 feet, velocities from 0.85 to 7.7 feet per second, energy gradients from 0.00001 to 0.1, temperatures from 36 to 90 degrees Fahrenheit, and Froude numbers from 0.07 to 1.7. It is concluded that the results, with adjustments for Froude number effects, are satisfactory throughout these ranges in variables except when the grain-associated tractive force for the median size of the bed-material mixture is less than about two times the critical tractive force. Within this same restriction, satisfactory results can be obtained without the Froude number adjustment when the Froude number is within the range from 0.10 to 0.30 (see boxed area in Figure 4.) This range of Froude numbers is characteristic of large alluvial rivers.

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DEVELOPMENT OF MODIFIED LAUSEN SEDIMENT RELATIONSHIP
BASED ON ARKANSAS RIVER DATA
BARBARELLE RANGES
June-July 1957

Range No.	Date	Water temp.	Station no range	g	V	Sediment size class	d	P ₆	P ₁₀	d ₆	T ₆	1 ₆	a	1 ₆	n	c	E	V	V for Bed Load	V for Total Load	Area of E each size	Area of V each size
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	17	19	20	21	22	23
3	6-27-57	74F																				
			626	24.80	5.23	WFS	.000285	.1	.033		.00114	.0324931		.2171545		.173	13.94	12687.20	20.91	12166.19	12.72	8842.47
						FS	.00058	.05	.136		.00232				.077	.00519	4.35	812.10	15.57	827.76	3.96	1297.69
						MS	.001150	.02	.57		.00463				.153	.00346	2.16	124.42	13.65	137.66	1.97	94.71
			826	19.50	6.63	WFS	.000285	.11	.033		.00114	.0283126		.1092191		.212	13.01	12972.90	20.55	12993.53		
						FS	.00058	.07	.136		.00232				.077	.01004	4.06	1066.25	15.30	1075.55		
						MS	.001150	.02	.57		.00463				.153	.00424	2.01	123.90	12.82	136.00		
			1226	14.80	4.50	WFS	.000285	.13	.033		.00114	.0303722		.2029823		.100	13.40	9161.16	20.74	9181.90		
						FS	.00058	.07	.136		.00232				.077	.01316	4.20	1100.01	15.44	1121.45		
						MS	.001150	.01	.57		.00463				.153	.00100	2.09	36.66	12.93	69.39		
			1626	14.40	3.62	WFS	.000285	.06	.033		.00114	.0170909		.1142210		.19	10.11	7504.89	19.20	7604.17		
						FS	.00058	.06	.136		.00232				.077	.0114	3.15	1765.52	14.36	1779.07		
						MS	.001150	.01	.57		.00463				.153	.0019	1.57	74.13	12.03	86.16		
			2026	9.80	6.14	WFS	.000285	.05	.033		.00114	.0204724		.1902850		.194	13.65	2603.97	20.57	2624.54		
						FS	.00058	.06	.136		.00232				.077	.01532	4.07	866.00	15.31	881.00		
						MS	.001150	.02	.57		.00463				.153	.00306	2.02	96.30	12.03	63.33		

TABLE III. 2

MODIFIED LARSEN METHOD
SEDIMENT LOAD CALCULATIONS

[illegible]

Appendix A

List of Symbols

c	sediment concentration of each grain size class, percent by weight
\bar{C}	total sediment concentration of all grain size classes, percent by weight
d	diameter of sediment particle (geometric mean of size class; $d = \sqrt{d_i * d_{i+1}}$ where i represents the lower bound and $i+1$ the upper bound of the size class), ft
d_m	median size of bed material, ft (i.e., D_{50})
D	depth of flow in a vertical, ft
$f()$	function of variable inclosed in the parentheses
F_r	Froude Number, V/\sqrt{gD}
g	gravitational acceleration, ft/sec/sec
n	roughness coefficient in Manning flow formula
P_b	fraction of bed material of diameter d , % by weight
P_s	fraction of suspended material of diameter d
q	flow per unit width, VD or Q/W , cfs/ft
q_s	sediment load per unit width, tons/day/ft
Q	total rate of flow in a cross section, cfs
Q_s	total bed material sediment discharge, tons/day

R	hydraulic radius of a channel cross section, ft
S	energy gradient, ft/ft
T_c	substitute symbol for τ_c , critical tractive force for beginning of sediment movement, lb/sq ft
T_o'	substitute symbol for τ_o , boundary shear or tractive force associated with sediment particles, lb/sq ft
TDF	temperature of water, degrees Fahrenheit
V	velocity of flow, ft/sec
w	fall velocity of sediment particle of size (or size class) d , ft/sec
W	surface width of channel cross section, ft
X	equivalent to $\sqrt{\tau_o/\rho/w}$ (also = $\sqrt{gDS/w}$ or $\sqrt{gRS/w}$), dimensionless
Y	function of X or $f(X)$ for suspended sediment concentration
Y'	$f(X)$ for total concentration including bed load
γ	specific weight of water, lb/cu ft
ρ	mass density of fluid, 1.94 for water, slugs/cu ft
τ_o	boundary shear or tractive force ($\approx \gamma DS$), lb/sq ft
$\sqrt{\tau_o/\rho}$	boundary shear velocity U_* (also = \sqrt{gDS}), ft/sec
Σ	sum

Appendix B Development of Modified Laursen Sediment Relationship Based on Arkansas River Data

TABLE NO. 8-1

Range No.	Date	Water Temp.	Station No.	Depth	Sediment size class	P ₄	P ₈	d ₅₀	T _c	T _o	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	aa	ab	ac	ad	ae	af	ag	ah	ai	aj	ak	al	am	an	ao	ap	aq	ar	as	at	au	av	aw	ax	ay	az	ba	bb	bc	bd	be	bf	bg	bh	bi	bj	bk	bl	bm	bn	bo	bp	bq	br	bs	bt	bu	bv	bw	bx	by	bz	ca	cb	cc	cd	ce	cf	cg	ch	ci	cj	ck	cl	cm	cn	co	cp	cq	cr	cs	ct	cu	cv	cw	cx	cy	cz	da	db	dc	dd	de	df	dg	dh	di	dj	dk	dl	dm	dn	do	dp	dq	dr	ds	dt	du	dv	dw	dx	dy	dz	ea	eb	ec	ed	ee	ef	eg	eh	ei	ej	ek	el	em	en	eo	ep	eq	er	es	et	eu	ev	ew	ex	ey	ez	fa	fb	fc	fd	fe	ff	fg	fh	fi	fj	fk	fl	fm	fn	fo	fp	fq	fr	fs	ft	fu	fv	fw	fx	fy	fz	ga	gb	gc	gd	ge	gf	gg	gh	gi	gj	gk	gl	gm	gn	go	gp	gq	gr	gs	gt	gu	gv	gw	gx	gy	gz	ha	hb	hc	hd	he	hf	hg	hh	hi	hj	hk	hl	hm	hn	ho	hp	hq	hr	hs	ht	hu	hv	hw	hx	hy	hz	ia	ib	ic	id	ie	if	ig	ih	ii	ij	ik	il	im	in	io	ip	iq	ir	is	it	iu	iv	iw	ix	iy	iz	ja	jb	jc	jd	je	jf	jj	jk	jl	jm	jn	jo	jp	jq	jr	js	jt	ju	jv	jw	jx	ky	kz	la	lb	lc	ld	le	lf	lg	lh	li	lj	lk	ll	lm	ln	lo	lp	lq	lr	ls	lt	lu	lv	lw	lx	ly	lz	ma	mb	mc	md	me	mf	mg	mh	mi	mj	mk	ml	mm	mn	mo	mp	mq	mr	ms	mt	mu	mv	mw	mx	my	mz	na	nb	nc	nd	ne	nf	ng	nh	ni	nj	nk	nl	nm	nn	no	np	nq	nr	ns	nt	nu	nv	nw	nx	ny	nz	oa	ob	oc	od	oe	of	og	oh	oi	oj	ok	ol	om	on	oo	op	oq	or	os	ot	ou	ov	ow	ox	oy	oz	pa	pb	pc	pd	pe	pf	pg	ph	pi	pj	pk	pl	pm	pn	po	pp	pq	pr	ps	pt	pu	pv	pw	px	py	pz	qa	qb	qc	qd	qe	qf	qg	qh	qi	qj	qk	ql	qm	qn	qo	qp	qq	qr	qs	qt	qu	qv	qw	qx	qy	qz	ra	rb	rc	rd	re	rf	rg	rh	ri	rj	rk	rl	rm	rn	ro	rp	rq	rr	rs	rt	ru	rv	rw	rx	ry	rz	sa	sb	sc	sd	se	sf	sg	sh	si	sj	sk	sl	sm	sn	so	sp	sq	sr	ss	st	su	sv	sw	sx	sy	sz	ta	tb	tc	td	te	tf	tg	th	ti	tj	tk	tl	tm	tn	to	tp	tq	tr	ts	tt	tu	tv	tw	tx	ty	tz	ua	ub	uc	ud	ue	uf	ug	uh	ui	uj	uk	ul	um	un	uo	up	uq	ur	us	ut	uu	uv	uw	ux	uy	uz	va	vb	vc	vd	ve	vf	vg	vh	vi	vj	vk	vl	vm	vn	vo	vp	vq	vr	vs	vt	vu	vv	vw	vx	vy	vz	wa	wb	wc	wd	we	wf	wg	wh	wi	wj	wk	wl	wm	wn	wo	wp	wq	wr	ws	wt	wu	wv	ww	wx	wy	wz	xa	xb	xc	xd	xe	xf	xg	xh	xi	xj	xk	xl	xm	xn	xo	xp	xq	xr	xs	xt	xu	xv	xw	xx	xy	xz	ya	yb	yc	yd	ye	yf	yg	yh	yi	yj	yk	yl	ym	yn	yo	yp	yq	yr	ys	yt	yu	yv	yw	yx	yy	yz	za	zb	zc	zd	ze	zf	zg	zh	zi	zj	zk	zl	zm	zn	zo	zp	zq	zr	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

TABLE NO. 8-2

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
 BASED ON ARKANSAS RIVER DATA
 MARSHVILLE DAMS
 June-July 1957

Range No.	Date	Water temp.	Station on range	S	V	Sediment size class	d	Ps	Ph	do	Tc	To	a	To	n	c	I	V	V for Bed Load	V' for Total Load	Av. of I each size	Av. of V' each size
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
7	6-28-57	71F								.001213												
			500	29.60	4.63	WF	.002285	.04	.033		.00114	.0277916		.1837993		.212	12.89	5126.16	20.50	5146.67	6513.44	
						FS	.000520	.025	.136		.00232					.024	4.82	722.57	15.27	737.83	4.82	
						MS	.001150	.005	.57		.00463					.077	2.00	33.78	12.79	46.57	2.00	
																.153						
			700	21.70	5.23	WF	.002285	.075	.033		.00114	.0306117		.2229668		.239	16.44	11329.75	21.10	11329.85		
						FS	.000520	.02	.136		.00232					.024	4.30	942.18	15.71	957.89		
						MS	.001150	.005	.57		.00463					.077	2.20	31.01	13.16	44.17		
																.153						
			900	25.20	6.10	WF	.002285	.09	.033		.00114	.0431189		.3015370		.245	16.03	10222.02	21.80	10233.82		
						FS	.000520	.03	.136		.00232					.024	5.12	754.70	16.23	770.93		
						MS	.001150	.02	.57		.00463					.077	2.50	133.83	13.60	136.43		
																.153						
			1300	22.20	6.71	WF	.002285	.09	.033		.00114	.0509199		.3004856		.226	18.46	6409.00	22.45	6431.45		
						FS	.000520	.025	.136		.00232					.024	5.75	392.82	16.72	408.74		
						MS	.001150	.025	.57		.00463					.077	2.06	87.00	14.81	101.00		
																.153						
			1500	21.50	5.49	WF	.002285	.09	.033		.00114	.0385328		.2575212		.225	15.18	9173.89	21.37	9195.26		
						FS	.000520	.03	.136		.00232					.024	4.75	600.62	15.91	606.53		
						MS	.001150	.01	.57		.00463					.077	2.35	31.50	13.33	44.83		
																.153						

TABLE NO. B-3

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON ARIZONA RIVER DATA
DANIELLE NAMES
June-July 1957

BMS53

Range No.	Date	Water temp.	Station on range	S	V	Sediment size class	P ₈	P ₆	P ₄	d ₈	T ₆	a	T ₆	a	c	Y	Y for Bed Load	Y for Total Load	Y for Ave. of 1 Ave. of Y			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
10	7-1-57	79F																				
			300	26.60	6.33	WFS	.000285	.15	.033		.00114	.0077177		.3109030		.241	16.22	10404.42	21.72	14528.35	13.97	2557.83
						FS	.000530	.03	.136		.00232					.025	3.29	745.45	16.29	761.74	4.48	675.33
						MS	.001130	.01	.57		.00463					.159	2.55	55.44	13.61	87.25	2.29	74.81
			700	17.20	5.23	WFS	.000285	.1	.033		.00114	.0376490		.2517332		.282	14.41	7229.37	21.07	7261.46		
						FS	.000530	.08	.136		.00232					.025	4.12	1415.30	15.81	1431.11		
						MS	.001130	.022	.57		.00463					.159	2.37	86.46	13.31	93.66		
			1100	16.70	6.70	WFS	.000285	.06	.033		.00114	.0368040		.2453402		.199	14.23	3344.87	21.03	3365.90		
						FS	.000530	.06	.136		.00232					.025	4.57	207.21	15.77	204.99		
						MS	.001130	.02	.57		.00463					.159	2.24	62.46	13.17	58.63		
			1700	13.00	6.40	WFS	.000285	.05	.033		.00114	.0272700		.1956104		.174	12.70	2946.58	20.45	2967.61		
						FS	.000530	.05	.136		.00232					.025	4.07	377.76	15.32	411.08		
						MS	.001130	.03	.57		.00463					.159	2.00	92.46	12.79	105.26		
			2300	8.00	3.92	WFS	.000285	.03	.033		.00114	.0273133		.1823394		.174	12.27	1864.16	20.25	1884.41		
						FS	.000530	.025	.136		.00232					.025	3.95	204.25	15.18	213.73		
						MS	.001130	.02	.57		.00463					.159	1.93	37.57	12.68	38.25		

TABLE NO. B-4

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON ARIZONA RIVER DATA
MANUELLE RANGES
June-July 1957

Range No.	Date	Water temp.	Station on range	S	V	Sediment size class	Ps	Ph	ds	Tc	To	n	c	S	V	V for Bed Load	V' for Total Load	Ass. of 1 Ass of V'				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
14	7-2-57	80F	240	38.49	7.40	WFS FS MS	.000285 .06 .001150	.1 .136 .02	.033 .136 .57	.00114 .00232 .00463	.002726	.029	.025	.216	17.05	14038.92	22.01	10046.95	13.98	9382.39		
			440	31.00	7.56	WFS FS MS	.000285 .06 .001150	.12 .136 .01	.033 .136 .57	.00114 .00232 .00463	.0046770	.029	.025	.220	18.00	11179.21	22.30	11294.79				
			640	26.30	5.49	WFS FS MS	.000285 .06 .001150	.07 .136 .02	.033 .136 .57	.00114 .00232 .00463	.0371095	.2616422	.025	.0133	14.49	5407.10	21.19	5638.30				
			840	26.00	3.00	WFS FS MS	.000285 .06 .001150	.07 .136 .02	.033 .136 .57	.00114 .00232 .00463	.0177140	.1317654	.025	.013795	10.42	10054.02	19.43	10073.46				
			1240	11.30	3.01	WFS FS MS	.000285 .06 .001150	.045 .136 .01	.033 .136 .57	.00114 .00232 .00463	.0163492	.0925353	.025	.007405	8.07	6728.76	18.43	6747.41				
													.070	.009715	2.04	871.06	13.99	885.04				
													.16	.00109	1.39	65.57	11.66	77.23				

DEVELOPMENT OF MODIFIED LAMBERT SEDIMENT RELATIONSHIP
BASED ON AVAILABLE DATA
REMARKS ATTENDING
6541 (144)
April 1954

Appendix B Development of Modified Laursen Sediment

TABLE NO. 3-4

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON ARKANSAS RIVER DATA
MARSHALLE HANES
April 1958

Range No.	Date	Water temp.	Station on range	S	V	Sediment size class	P ₄	P ₆	P ₈	P ₁₀	P ₁₂	P ₁₄	P ₁₆	P ₁₈	P ₂₀	P ₂₂	P ₂₄	P ₂₆	P ₂₈	P ₃₀	P ₃₂	P ₃₄	P ₃₆	P ₃₈	P ₄₀	P ₄₂	P ₄₄	P ₄₆	P ₄₈	P ₅₀	P ₅₂	P ₅₄	P ₅₆	P ₅₈	P ₆₀	P ₆₂	P ₆₄	P ₆₆	P ₆₈	P ₇₀	P ₇₂	P ₇₄	P ₇₆	P ₇₈	P ₈₀	P ₈₂	P ₈₄	P ₈₆	P ₈₈	P ₉₀	P ₉₂	P ₉₄	P ₉₆	P ₉₈	P ₁₀₀	P ₁₀₂	P ₁₀₄	P ₁₀₆	P ₁₀₈	P ₁₁₀	P ₁₁₂	P ₁₁₄	P ₁₁₆	P ₁₁₈	P ₁₂₀	P ₁₂₂	P ₁₂₄	P ₁₂₆	P ₁₂₈	P ₁₃₀	P ₁₃₂	P ₁₃₄	P ₁₃₆	P ₁₃₈	P ₁₄₀	P ₁₄₂	P ₁₄₄	P ₁₄₆	P ₁₄₈	P ₁₅₀	P ₁₅₂	P ₁₅₄	P ₁₅₆	P ₁₅₈	P ₁₆₀	P ₁₆₂	P ₁₆₄	P ₁₆₆	P ₁₆₈	P ₁₇₀	P ₁₇₂	P ₁₇₄	P ₁₇₆	P ₁₇₈	P ₁₈₀	P ₁₈₂	P ₁₈₄	P ₁₈₆	P ₁₈₈	P ₁₉₀	P ₁₉₂	P ₁₉₄	P ₁₉₆	P ₁₉₈	P ₂₀₀	P ₂₀₂	P ₂₀₄	P ₂₀₆	P ₂₀₈	P ₂₁₀	P ₂₁₂	P ₂₁₄	P ₂₁₆	P ₂₁₈	P ₂₂₀	P ₂₂₂	P ₂₂₄	P ₂₂₆	P ₂₂₈	P ₂₃₀	P ₂₃₂	P ₂₃₄	P ₂₃₆	P ₂₃₈	P ₂₄₀	P ₂₄₂	P ₂₄₄	P ₂₄₆	P ₂₄₈	P ₂₅₀	P ₂₅₂	P ₂₅₄	P ₂₅₆	P ₂₅₈	P ₂₆₀	P ₂₆₂	P ₂₆₄	P ₂₆₆	P ₂₆₈	P ₂₇₀	P ₂₇₂	P ₂₇₄	P ₂₇₆	P ₂₇₈	P ₂₈₀	P ₂₈₂	P ₂₈₄	P ₂₈₆	P ₂₈₈	P ₂₉₀	P ₂₉₂	P ₂₉₄	P ₂₉₆	P ₂₉₈	P ₃₀₀	P ₃₀₂	P ₃₀₄	P ₃₀₆	P ₃₀₈	P ₃₁₀	P ₃₁₂	P ₃₁₄	P ₃₁₆	P ₃₁₈	P ₃₂₀	P ₃₂₂	P ₃₂₄	P ₃₂₆	P ₃₂₈	P ₃₃₀	P ₃₃₂	P ₃₃₄	P ₃₃₆	P ₃₃₈	P ₃₄₀	P ₃₄₂	P ₃₄₄	P ₃₄₆	P ₃₄₈	P ₃₅₀	P ₃₅₂	P ₃₅₄	P ₃₅₆	P ₃₅₈	P ₃₆₀	P ₃₆₂	P ₃₆₄	P ₃₆₆	P ₃₆₈	P ₃₇₀	P ₃₇₂	P ₃₇₄	P ₃₇₆	P ₃₇₈	P ₃₈₀	P ₃₈₂	P ₃₈₄	P ₃₈₆	P ₃₈₈	P ₃₉₀	P ₃₉₂	P ₃₉₄	P ₃₉₆	P ₃₉₈	P ₄₀₀	P ₄₀₂	P ₄₀₄	P ₄₀₆	P ₄₀₈	P ₄₁₀	P ₄₁₂	P ₄₁₄	P ₄₁₆	P ₄₁₈	P ₄₂₀	P ₄₂₂	P ₄₂₄	P ₄₂₆	P ₄₂₈	P ₄₃₀	P ₄₃₂	P ₄₃₄	P ₄₃₆	P ₄₃₈	P ₄₄₀	P ₄₄₂	P ₄₄₄	P ₄₄₆	P ₄₄₈	P ₄₅₀	P ₄₅₂	P ₄₅₄	P ₄₅₆	P ₄₅₈	P ₄₆₀	P ₄₆₂	P ₄₆₄	P ₄₆₆	P ₄₆₈	P ₄₇₀	P ₄₇₂	P ₄₇₄	P ₄₇₆	P ₄₇₈	P ₄₈₀	P ₄₈₂	P ₄₈₄	P ₄₈₆	P ₄₈₈	P ₄₉₀	P ₄₉₂	P ₄₉₄	P ₄₉₆	P ₄₉₈	P ₅₀₀	P ₅₀₂	P ₅₀₄	P ₅₀₆	P ₅₀₈	P ₅₁₀	P ₅₁₂	P ₅₁₄	P ₅₁₆	P ₅₁₈	P ₅₂₀	P ₅₂₂	P ₅₂₄	P ₅₂₆	P ₅₂₈	P ₅₃₀	P ₅₃₂	P ₅₃₄	P ₅₃₆	P ₅₃₈	P ₅₄₀	P ₅₄₂	P ₅₄₄	P ₅₄₆	P ₅₄₈	P ₅₅₀	P ₅₅₂	P ₅₅₄	P ₅₅₆	P ₅₅₈	P ₅₆₀	P ₅₆₂	P ₅₆₄	P ₅₆₆	P ₅₆₈	P ₅₇₀	P ₅₇₂	P ₅₇₄	P ₅₇₆	P ₅₇₈	P ₅₈₀	P ₅₈₂	P ₅₈₄	P ₅₈₆	P ₅₈₈	P ₅₉₀	P ₅₉₂	P ₅₉₄	P ₅₉₆	P ₅₉₈	P ₆₀₀	P ₆₀₂	P ₆₀₄	P ₆₀₆	P ₆₀₈	P ₆₁₀	P ₆₁₂	P ₆₁₄	P ₆₁₆	P ₆₁₈	P ₆₂₀	P ₆₂₂	P ₆₂₄	P ₆₂₆	P ₆₂₈	P ₆₃₀	P ₆₃₂	P ₆₃₄	P ₆₃₆	P ₆₃₈	P ₆₄₀	P ₆₄₂	P ₆₄₄	P ₆₄₆	P ₆₄₈	P ₆₅₀	P ₆₅₂	P ₆₅₄	P ₆₅₆	P ₆₅₈	P ₆₆₀	P ₆₆₂	P ₆₆₄	P ₆₆₆	P ₆₆₈	P ₆₇₀	P ₆₇₂	P ₆₇₄	P ₆₇₆	P ₆₇₈	P ₆₈₀	P ₆₈₂	P ₆₈₄	P ₆₈₆	P ₆₈₈	P ₆₉₀	P ₆₉₂	P ₆₉₄	P ₆₉₆	P ₆₉₈	P ₇₀₀	P ₇₀₂	P ₇₀₄	P ₇₀₆	P ₇₀₈	P ₇₁₀	P ₇₁₂	P ₇₁₄	P ₇₁₆	P ₇₁₈	P ₇₂₀	P ₇₂₂	P ₇₂₄	P ₇₂₆	P ₇₂₈	P ₇₃₀	P ₇₃₂	P ₇₃₄	P ₇₃₆	P ₇₃₈	P ₇₄₀	P ₇₄₂	P ₇₄₄	P ₇₄₆	P ₇₄₈	P ₇₅₀	P ₇₅₂	P ₇₅₄	P ₇₅₆	P ₇₅₈	P ₇₆₀	P ₇₆₂	P ₇₆₄	P ₇₆₆	P ₇₆₈	P ₇₇₀	P ₇₇₂	P ₇₇₄	P ₇₇₆	P ₇₇₈	P ₇₈₀	P ₇₈₂	P ₇₈₄	P ₇₈₆	P ₇₈₈	P ₇₉₀	P ₇₉₂	P ₇₉₄	P ₇₉₆	P ₇₉₈	P ₈₀₀	P ₈₀₂	P ₈₀₄	P ₈₀₆	P ₈₀₈	P ₈₁₀	P ₈₁₂	P ₈₁₄	P ₈₁₆	P ₈₁₈	P ₈₂₀	P ₈₂₂	P ₈₂₄	P ₈₂₆	P ₈₂₈	P ₈₃₀	P ₈₃₂	P ₈₃₄	P ₈₃₆	P ₈₃₈	P ₈₄₀	P ₈₄₂	P ₈₄₄	P ₈₄₆	P ₈₄₈	P ₈₅₀	P ₈₅₂	P ₈₅₄	P ₈₅₆	P ₈₅₈	P ₈₆₀	P ₈₆₂	P ₈₆₄	P ₈₆₆	P ₈₆₈	P ₈₇₀	P ₈₇₂	P ₈₇₄	P ₈₇₆	P ₈₇₈	P ₈₈₀	P ₈₈₂	P ₈₈₄	P ₈₈₆	P ₈₈₈	P ₈₉₀	P ₈₉₂	P ₈₉₄	P ₈₉₆	P ₈₉₈	P ₉₀₀	P ₉₀₂	P ₉₀₄	P ₉₀₆	P ₉₀₈	P ₉₁₀	P ₉₁₂	P ₉₁₄	P ₉₁₆	P ₉₁₈	P ₉₂₀	P ₉₂₂	P ₉₂₄	P ₉₂₆	P ₉₂₈	P ₉₃₀	P ₉₃₂	P ₉₃₄	P ₉₃₆	P ₉₃₈	P ₉₄₀	P ₉₄₂	P ₉₄₄	P ₉₄₆	P ₉₄₈	P ₉₅₀	P ₉₅₂	P ₉₅₄	P ₉₅₆	P ₉₅₈	P ₉₆₀	P ₉₆₂	P ₉₆₄	P ₉₆₆	P ₉₆₈	P ₉₇₀	P ₉₇₂	P ₉₇₄	P ₉₇₆	P ₉₇₈	P ₉₈₀	P ₉₈₂	P ₉₈₄	P ₉₈₆	P ₉₈₈	P ₉₉₀	P ₉₉₂	P ₉₉₄	P ₉₉₆	P ₉₉₈	P ₁₀₀₀	P ₁₀₀₂	P ₁₀₀₄	P ₁₀₀₆	P ₁₀₀₈	P ₁₀₁₀	P ₁₀₁₂	P ₁₀₁₄	P ₁₀₁₆	P ₁₀₁₈	P ₁₀₂₀	P ₁₀₂₂	P ₁₀₂₄	P ₁₀₂₆	P ₁₀₂₈	P ₁₀₃₀	P ₁₀₃₂	P ₁₀₃₄	P ₁₀₃₆	P ₁₀₃₈	P ₁₀₄₀	P ₁₀₄₂	P ₁₀₄₄	P ₁₀₄₆	P ₁₀₄₈	P ₁₀₅₀	P ₁₀₅₂	P ₁₀₅₄	P ₁₀₅₆	P ₁₀₅₈	P ₁₀₆₀	P ₁₀₆₂	P ₁₀₆₄	P ₁₀₆₆	P ₁₀₆₈	P ₁₀₇₀	P ₁₀₇₂	P ₁₀₇₄	P ₁₀₇₆	P ₁₀₇₈	P ₁₀₈₀	P ₁₀₈₂	P ₁₀₈₄	P ₁₀₈₆	P ₁₀₈₈	P ₁₀₉₀	P ₁₀₉₂	P ₁₀₉₄	P ₁₀₉₆	P ₁₀₉₈	P ₁₁₀₀	P ₁₁₀₂	P ₁₁₀₄	P ₁₁₀₆	P ₁₁₀₈	P ₁₁₁₀	P ₁₁₁₂	P ₁₁₁₄	P ₁₁₁₆	P ₁₁₁₈	P ₁₁₂₀	P ₁₁₂₂	P ₁₁₂₄	P ₁₁₂₆	P ₁₁₂₈	P ₁₁₃₀	P ₁₁₃₂	P ₁₁₃₄	P ₁₁₃₆	P ₁₁₃₈	P ₁₁₄₀	P ₁₁₄₂	P ₁₁₄₄	P ₁₁₄₆	P ₁₁₄₈	P ₁₁₅₀	P ₁₁₅₂	P ₁₁₅₄	P ₁₁₅₆	P ₁₁₅₈	P ₁₁₆₀	P ₁₁₆₂	P ₁₁₆₄	P ₁₁₆₆	P ₁₁₆₈	P ₁₁₇₀	P ₁₁₇₂	P ₁₁₇₄	P ₁₁₇₆	P ₁₁₇₈	P ₁₁₈₀	P ₁₁₈₂	P ₁₁₈₄	P ₁₁₈₆	P ₁₁₈₈	P ₁₁₉₀	P ₁₁₉₂	P ₁₁₉₄	P ₁₁₉₆	P ₁₁₉₈	P ₁₂₀₀	P ₁₂₀₂	P ₁₂₀₄	P ₁₂₀₆	P ₁₂₀₈	P ₁₂₁₀	P ₁₂₁₂	P ₁₂₁₄	P ₁₂₁₆	P ₁₂₁₈	P ₁₂₂₀	P ₁₂₂₂	P ₁₂₂₄	P ₁₂₂₆	P ₁₂₂₈	P ₁₂₃₀	P ₁₂₃₂	P ₁₂₃₄	P ₁₂₃₆	P ₁₂₃₈	P ₁₂₄₀	P ₁₂₄₂	P ₁₂₄₄	P ₁₂₄₆	P ₁₂₄₈	P ₁₂₅₀	P ₁₂₅₂	P ₁₂₅₄	P ₁₂₅₆	P ₁₂₅₈	P ₁₂₆₀	P ₁₂₆₂	P ₁₂₆₄	P ₁₂₆₆	P ₁₂₆₈	P ₁₂₇₀	P ₁₂₇₂	P ₁₂₇₄	P ₁₂₇₆	P ₁₂₇₈	P ₁₂₈₀	P ₁₂₈₂	P ₁₂₈₄	P ₁₂₈₆	P ₁₂₈₈	P ₁₂₉₀	P ₁₂₉₂	P ₁₂₉₄	P ₁₂₉₆	P ₁₂₉₈	P ₁₃₀₀	P ₁₃₀₂	P ₁₃₀₄	P ₁₃₀₆	P ₁₃₀₈	P ₁₃₁₀	P ₁₃₁₂	P ₁₃₁₄	P ₁₃₁₆	P ₁₃₁₈	P ₁₃₂₀	P ₁₃₂₂	P ₁₃₂₄	P ₁₃₂₆	P ₁₃₂₈	P ₁₃₃₀	P ₁₃₃₂	P ₁₃₃₄	P ₁₃₃₆	P ₁₃₃₈	P ₁₃₄₀	P ₁₃₄₂	P ₁₃₄₄	P ₁₃₄₆	P ₁₃₄₈	P ₁₃₅₀	P ₁₃₅₂	P ₁₃₅₄	P ₁₃₅₆	P ₁₃₅₈	P ₁₃₆₀	P ₁₃₆₂	P ₁₃₆₄	P ₁₃₆₆	P ₁₃₆₈	P ₁₃₇₀	P ₁₃₇₂	P ₁₃₇₄	P ₁₃₇₆	P ₁₃₇₈	P ₁₃₈₀	P ₁₃₈₂	P ₁₃₈₄	P ₁₃₈₆	P ₁₃₈₈	P ₁₃₉₀	P ₁₃₉₂	P ₁₃₉₄	P ₁₃₉₆	P ₁₃₉₈	P ₁₄₀₀	P ₁₄₀₂	P ₁₄₀₄	P ₁₄₀₆	P ₁₄₀₈	P ₁₄₁₀	P ₁₄₁₂	P ₁₄₁₄	P ₁₄₁₆	P ₁₄₁₈	P ₁₄₂₀	P ₁₄₂₂	P ₁₄₂₄	P ₁₄₂₆	P ₁₄₂₈	P ₁₄₃₀	P ₁₄₃₂	P ₁₄₃₄	P ₁₄₃₆	P ₁₄₃₈	P ₁₄₄₀	P ₁₄₄₂	P ₁₄₄₄	P ₁₄₄₆	P ₁₄₄₈	P ₁₄₅₀	P ₁₄₅₂	P ₁₄₅₄	P ₁₄₅₆	P ₁₄₅₈	P ₁₄₆₀	P ₁₄₆₂	P ₁₄₆₄	P ₁₄₆₆	P ₁₄₆₈	P ₁₄₇₀	P ₁₄₇₂	P ₁₄₇₄	P ₁₄₇₆	P ₁₄₇₈	P ₁₄₈₀	P ₁₄₈₂	P ₁₄₈₄	P ₁₄₈₆	P ₁₄₈₈	P ₁₄₉₀	P ₁₄₉₂	P ₁₄₉₄	P ₁₄₉₆	P ₁₄₉₈	P ₁₅₀₀	P ₁₅₀₂	P ₁₅₀₄	P ₁₅₀₆	P ₁₅₀₈	P ₁₅₁₀	P ₁₅₁₂	P ₁₅₁₄	P ₁₅₁₆	P ₁₅₁₈	P ₁₅₂₀	P ₁₅₂₂	P ₁₅₂₄	P ₁₅₂₆	P ₁₅₂₈	P ₁₅₃₀	P ₁₅₃₂	P ₁₅₃₄	P ₁₅₃₆	P ₁₅₃₈	P ₁₅₄₀	P ₁₅₄₂	P ₁₅₄₄	P ₁₅₄₆	P ₁₅₄₈	P ₁₅₅₀	P ₁₅₅₂	P ₁₅₅₄	P ₁₅₅₆	P ₁₅₅₈	P ₁₅₆₀	P ₁₅₆₂	P ₁₅₆₄	P ₁₅₆₆	P ₁₅₆₈	P ₁₅₇₀	P ₁₅₇₂	P ₁₅₇₄	P ₁₅₇₆	P ₁₅₇₈	P ₁₅₈₀	P ₁₅₈₂	P ₁₅₈₄	P ₁₅₈₆	P ₁₅₈₈	P ₁₅₉₀	P ₁₅₉₂	P ₁₅₉₄	P ₁₅₉₆	P ₁₅₉₈	P ₁₆₀₀	P ₁₆₀₂	P ₁₆₀₄	P ₁₆₀₆	P ₁₆₀₈	P ₁₆₁₀	P ₁₆₁₂	P ₁₆₁₄	P ₁₆₁₆	P ₁₆₁₈	P ₁₆₂₀	P ₁₆₂₂	P ₁₆₂₄	P ₁₆₂₆	P ₁₆₂₈	P ₁₆₃₀	P ₁₆₃₂	P ₁₆₃₄	P ₁₆₃₆	P ₁₆₃₈	P ₁₆₄₀	P ₁₆₄₂	P ₁₆₄₄	P ₁₆₄₆	P ₁₆₄₈	P ₁₆₅₀	P ₁₆₅₂	P ₁₆₅₄	P ₁₆₅₆	P ₁₆₅₈	P ₁₆₆₀	P ₁₆₆₂	P ₁₆₆₄	P ₁₆₆₆	P ₁₆₆₈	P ₁₆₇₀	P ₁₆₇₂	P ₁₆₇₄	P ₁₆₇₆	P ₁₆₇₈	P ₁₆₈₀	P ₁₆₈₂	P ₁₆₈₄	P ₁₆₈₆	P ₁₆₈₈	P ₁₆₉₀	P ₁₆₉₂	P ₁₆₉₄	P ₁₆₉₆	P ₁₆₉₈	P ₁₇₀₀	P ₁₇₀₂	P ₁₇₀₄	P ₁₇₀₆	P ₁₇₀₈	P ₁₇₁₀	P ₁₇₁₂	P ₁₇₁₄	P ₁₇₁₆	P ₁₇₁₈	P ₁₇₂₀	P ₁₇₂₂	P ₁₇₂₄	P ₁₇₂₆	P ₁₇₂₈	P ₁₇₃₀	P ₁₇₃₂	P ₁₇₃₄	P ₁₇₃₆	P ₁₇₃₈	P ₁₇₄₀	P ₁₇₄₂	P ₁₇₄₄	P ₁₇₄₆	P ₁₇₄₈	P ₁₇₅₀	P ₁₇₅₂	P ₁₇₅₄	P ₁₇₅₆	P ₁₇₅₈	P ₁₇₆₀	P ₁₇₆₂	P ₁₇₆₄	P ₁₇₆₆	P ₁₇₆₈	P ₁₇₇₀	P ₁₇₇₂	P ₁₇₇₄	P ₁₇₇₆	P ₁₇₇₈	P ₁₇₈₀	P ₁₇₈₂	P ₁₇₈₄	P ₁₇₈₆	P ₁₇₈₈	P ₁₇₉₀	P ₁₇₉₂	P ₁₇₉₄	P ₁₇₉₆	P ₁₇₉₈	P ₁₈₀₀	P ₁₈₀₂	P ₁₈₀₄	P ₁₈₀₆	P ₁₈₀₈	P ₁₈₁₀	P ₁₈₁₂	P ₁₈₁₄	P ₁₈₁₆	P ₁₈₁₈	P ₁₈₂₀	P<
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0541 1149
SEAN O'NEILL
WIA 0418 5700000 0000
ATTENTION: AMERICAN RESORTS CORPORATION

Range No.	Date	Water temp.	Station no. range	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23				
0	0-1-30	52	296	11.20	3.72		W3	.000285	.46	.033		.00116	.0217948	.1263660	.0175	.0135	16.28	5373.32	21.13	5396.08	14.91	11199.33					
							F3	.000280	.025	.136		.00732			.061	.00935	4.18	894.85	15.42	894.25	4.28	944.96					
							MS	.001128	.01	.57		.00463			.16	.00617	1.82	37.04	12.59	61.54	1.85	96.4					
														.027													

DEVELOPMENT OF MODIFIED LANDFILL SEDIMENT RELATIONSHIP
BASED ON ALCANTARA OLIVER DATA
BARBARELLE RAMES
April 1990

B9

DEVELOPMENT OF MODIFIED LAMPSEN SEDIMENT RELATIONSHIP
BASED ON ANIKIAS RIVER DATA
NORTH LUTON DAMGES

[illegible]

TABLE NO. 8-10

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON ARKANSAS RIVER DATA
HAMILTON DAMS
April 1958

Range No.	Date	Water Temp.	Station on range	S	V	Sediment size class	Ph	do	Tc	To	e	To	e	c	I	V	V for Bed Load	V for Total Load	Ave. of I for each size	Ave. of V for each size	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
7	4-7-58	55F	1300	2.40	2.70	WFS FS MS	.00285 .2185 .001158	.03 .2185 .4945	.00114 .00232 .00463	.0175343	.002595	.0175 .001 .16	.00372 .00168 .00956	12.21 3.59 1.53	532.46 17.36 2.62	26.22 14.75 11.95	532.46 32.11 14.57	12.44 3.71 1.62	1344.96 281.00 62.74		
			1400	9.00	3.20	WFS FS MS	.00285 .2185 .001158	.03 .2185 .4945	.00114 .00232 .00463	.01757019	.0018029	.0175 .001 .16	.00372 .00168 .00976	11.75 3.37 1.47	7405.93 44.41 26.65	26.02 14.66 11.83	7405.93 37.01 32.26				
			1900	23.50	4.59	WFS FS MS	.00285 .2185 .001158	.03 .2185 .4945	.00114 .00232 .00463	.0261470	.1194861	.0175 .001 .16	.03228 .00168 .00174	10.19 4.07 1.77	31642.70 754.65 79.92	21.01 15.32 12.41	31643.71 751.77 92.34				
			2200	23.50	5.32	WFS FS MS	.00285 .2185 .001158	.03 .2185 .4945	.00114 .00232 .00463	.0251263	.1607833	.0175 .001 .16	.03225 .00211 .00125	14.45 4.72 2.66	19798.10 278.24 59.23	21.01 15.90 12.07	19819.91 250.16 65.12				
			2500	26.00	3.32	WFS FS MS	.00285 .2185 .001158	.03 .2185 .4945	.00114 .00232 .00463	.0132267	.0605428	.0175 .001 .16	.00452 .00113 0	10.49 2.90 1.26	6676.25 273.92 .00	-19.27 14.68 11.37	6717.32 267.97 11.39				

TABLE NO. 9-11

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON OKLAHOMA RIVER DATA
MODIFICATION DATES
April 1958

Range No.	Date	Water temp.	Station on range	Q	V	Sediment size class	PS	ds	fc	To'	o	To	u	c	l	V	V for Bed Load	V for Total Load	Ans. of l each size	Ans. of V each size								
I	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22							
II	4-7-58	55F	370	14.00	3.02	WS	.000205	.03	.00110	.0169335	.0775106	.0175	.0203	11.02	21975.19	19.09	21615.00	12.63	19440.87	423.02	23.76							
						FS	.000205	.2105	.00232													.001	.0020	3.20	583.39	10.50	597.09	3.62
						MS	.001150	.0965	.00463													.10	0	1.03	.00	11.75	11.75	1.50
			640	19.00	4.32	WS	.000205	.03	.00110	.0203133	.112501	.0175	.03	13.75	21716.32	20.04	21737.36											
						FS	.000205	.2105	.00232													.001	.006	3.94	537.09	15.19	573.00	
						MS	.001150	.0965	.00463													.10	0	1.72	.00	12.31	12.31	
			970	20.70	3.03	WS	.000205	.03	.00110	.0109921	.0049326	.0175	.033	12.10	32954.99	20.10	32975.16											
						FS	.000205	.2105	.00232													.001	.00071	3.07	616.20	14.71	630.99	
						MS	.001150	.0965	.00463													.10	0	1.51	.00	11.92	11.92	
			1270	15.00	3.53	WS	.000205	.03	.00110	.0170540	.0017132	.0175	.0220	11.73	17705.34	20.02	17765.36											
						FS	.000205	.2105	.00232													.001	.00220	3.36	222.07	14.60	207.47	
						MS	.001150	.0965	.00463													.10	.00076	1.07	35.75	11.03	47.37	
			1500	16.70	4.33	WS	.000205	.03	.00110	.0260757	.1192561	.0175	.00733	14.17	6090.40	21.00	6111.41											
						FS	.000205	.2105	.00232													.001	.000733	4.07	52.37	15.31	47.40	
						MS	.001150	.0965	.00463													.10	.000733	1.77	22.76	12.41	35.15	

TABLE NO. 8-12

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON ARIZONA RIVER DATA
HOBBSVILLE RANGES
April 1958

Range No.	Date	Water temp.	Station on range	Q	V	Sediment size class	Ph	do	Tc	To	a	To	v	c	E	V	V for Bed load	V for Total load	Av. of 1 each size	Av. of 1 each size	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
24	6-7-58	55F	246	25.36	4.16	WF3 FS RS	.000725 .2185 .0965	.03 .2185 .0965	.00116 .00232 .00463	.0207532	.024	.0750024	.0175 .061 .16	.0103 .0024 0	.0103 3.43 1.38	12.45 337.75 .00	16425.00 14.88 12.06	26.46 372.62 12.06	16445.00 372.62 12.06	15.46 4.44 1.94	16113.26 368.02 68.23
			650	19.00	4.25	WF3 FS RS	.000285 .2185 .0965	.03 .2185 .0965	.00116 .00232 .00463	.0237350	.1006418	.0175 .061 .16	.0195 .0039 .0026	13.52 3.88 1.49	16408.21 375.98 110.16	26.75 15.13 12.26	16428.96 391.11 122.40				
			660	16.00	4.02	WF3 FS RS	.000285 .2185 .0965	.03 .2185 .0965	.00116 .00232 .00463	.0322471	.1076042	.0175 .061 .16	.0417 .0209 .0017	15.76 6.52 1.97	18732.80 1199.27 41.13	21.57 15.73 12.75	18754.37 1206.00 35.88				
			800	16.00	5.01	WF3 FS RS	.000285 .2185 .0965	.03 .2185 .0965	.00116 .00232 .00463	.0448542	.2144652	.0175 .061 .16	.0401 .00996 .00167	19.06 3.45 2.37	14763.47 381.10 26.43	22.42 16.49 15.56	14726.06 397.67 29.79				
			1000	10.50	4.66	WF3 FS RS	.000285 .2185 .0965	.03 .2185 .0965	.00116 .00232 .00463	.0323239	.1613676	.0175 .061 .16	.0253 .00474 .00158	16.48 4.73 2.06	2409.27 141.76 19.92	21.02 15.91 12.89	2411.09 157.67 32.81				

TABLE NO. B-13

DEVELOPMENT OF MODIFIED LAURSEN SEDIMENT RELATIONSHIP
BASED ON ARKANSAS RIVER DATA

Computation of Group Averages of Data Points

Location	Date	Range	Sediment Size Class					
			Very Fine Sand		Fine Sand		Medium Sand	
			Ave. Y'	Ave. Y'	Ave. Y'	Ave. Y'	Ave. Y'	Ave. Y'
Burdanville	June-July 1957	3	12.72	8842.47	3.96	1297.49	1.97	94.71
"	"	7	15.48	8513.61	6.82	634.38	2.46	74.44
"	"	10	13.97	5857.83	4.48	679.33	2.26	74.81
"	"	14	15.96	9582.39	6.48	1361.11	2.18	113.07
Burdanville	June-July 1957	Average	14.04	8130.00	4.44	978.13	2.19	96.01
Burdanville	April 1958	Bridge	15.89	10334.48	6.56	1379.78	1.99	133.94
"	"	3	15.59	9614.00	4.47	656.33	1.95	47.81
"	"	8	14.91	11109.33	6.20	944.96	1.83	98.44
"	"	13	14.73	10776.09	4.23	776.28	1.81	96.57
Burdanville	April 1958	Average	15.28	11458.00	4.39	888.04	1.90	96.49
Herrilton	April 1958	5	12.12	19618.00	2.48	389.20	1.31	73.22
"	"	7	12.94	13443.96	3.71	281.00	1.62	42.74
"	"	11	12.43	19446.87	3.42	423.82	1.58	23.74
"	"	24	15.48	10113.26	4.44	585.82	1.94	45.23
Herrilton	April 1958	Average	13.29	16604.04	3.56	437.39	1.64	51.23
OVERALL AVERAGE			14.20	12065.64	4.13	768.12	1.92	77.31

Appendix C

Modified Laursen Method

Sediment Load Calculations

TABLE NO. C-1
MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location and date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22									
																							Bed Composition	c	Bed-Material Sediment Load Tons Per Day	Ratio Comp/obs	Fr	Adjusted Comp/obs	Adjusted Load Tons/Day	Adjusted Ratio Comp/obs	Adjusted Load Tons/Day
Atchafalaya R., Slomport, La. April 12, 1962																															
		4.20	40.3	1651	.0004972		59	WFS	.000283	.049	.017	14.35	1300	.013704	68212.33																
								FS	.00028	.717	.044	4.32	800	.013045	174519.95																
								MS	.00128	.23	.104	1.92	76	.000197	2023.04																
								CS	.00232	.002	.237	1.00	21.7	.000009	12.00																
								WCS	.00444	0	.305	.72	12.7	0	.00																
								Median	.00056																						
								Total							343301.49	.54		309663.33	.46	187.20	410.05										
Atchafalaya R., Slomport, La. May 24, 1961																															
		5.68	46.6	1562	.0004645		70	WFS	.000285	.076	.021	12.00	900	.010725	142323.13																
								FS	.00028	.771	.072	3.47	360	.007169	82941.04																
								MS	.00128	.109	.154	1.71	54	.000197	1804.19																
								CS	.00232	.002	.261	1.04	19	.000006	7.00																
								WCS	.00444	0	.305	.69	12	0	.00																
								Median	.00059																						
								Total							229853.56	.53		210797.00	.40	134.95	280.25										
Atchafalaya R., Slomport, La. March 18, 1963																															
		5.91	45.3	1353	.0003700		50	WFS	.000285	.145	.010	14.33	12700	.027400	222719.36																
								FS	.00028	.612	.050	4.12	760	.000003	47780.06																
								MS	.00128	.104	.122	1.75	29	.000134	1145.71																
								CS	.00232	.023	.232	.95	17	.000039	31.03																
								WCS	.00444	0	.305	.63	12	0	.00																
								Median	.00056																						
								Total							271634.11	.61		200000.00	1.46	207.31	182.13										
Atchafalaya R., Slomport, La. December 10, 1964																															
		4.49	38.6	1270	.0002716		46	WFS	.000285	.262	.017	9.31	2250	.022239	105906.00																
								FS	.00028	.044	.045	2.92	260	.001212	8221.09																
								MS	.00128	.015	.133	1.22	27	.000062	29.34																
								CS	.00232	.002	.232	.85	12	.000002	1.00																
								WCS	.00444	0	.305	.43	9	0	.00																
								Median	.00320																						
								Total							110791.31	.96		107133.39	.90	86.26	94.02										
Atchafalaya R., Slomport, La. August 11, 1966																															
		1.92	22.1	1030	.0000113		66	WFS	.000285	.562	.016	5.34	300	.000437	200.20																
								FS	.00028	.312	.061	1.10	22	.000000	9.91																
								MS	.00128	.037	.161	.85	11	.000002	-1.77																
								CS	.00232	0	.266	.33	0	0	.00																
								WCS	.00444	0	.305	.23	7	0	.00																
								Median	.00305																						
								Total							516.10	.23		901.59	.40	.00	.00	2.10									

TABLE NR. C-2

MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Atchafalaya River, Stennisport, Louisiana April 26, 1965	427000	6.35	45.10	1500	.0000305	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285
Atchafalaya River, Stennisport, Louisiana April 7, 1965	561000	5.62	43.40	1000	.0000443	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285
Atchafalaya River, Stennisport, Louisiana February 19, 1965	270000	5.82	38.20	1500	.0000305	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285
Atchafalaya River, Stennisport, Louisiana May 19, 1964	96400	5.12	27.00	1150	.000019	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285
Atchafalaya River, Stennisport, Louisiana September 18, 1964	61000	5.97	21.70	1000	.0000100	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285	.00285

MODIFIED LAURENSEN METHOD
SEDIMENT LOAD CALCULATIONS

Appendix C Modified Laursen Method Sediment Load Calculations

TABLE NO. C-4

MODIFIED LAUREN METHOD
SEDIMENT LOAD CALCULATIONS

Location Date	Q	V	S	TSS	Bed Composition		S	V _c	I	B	C	Bed-Material Sediment Load Tons Per Day		Ratio Comp/obs	Fr	Adjusted Comp/obs		Adjusted Load Tons/Day	Adjusted Load Tons/Day/Ft		
					Size Dist. No.							Computed							Computed		
					8	9		10	11	12	13	14	15	16	17	18	19	20			21
Mississippi R., St. Louis, Missouri April 6, 1963																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
							WTS	.000285	.04	.01675	15.06	19000	.0137408	101803.41			.15	103141.02			
							FS	.00028	.37	.0285	4.54	920	.0001379	6488.97				9481.95			
							MS	.00128	.07	.1375	1.94	70	.0001307	6611.16				1016.94			
							CS	.00232	.35	.255	1.65	21	.0001567	1176.31				1176.04			
							WCS	.00444	.16	.385	.49	12.3	.0000166	124.53				124.29			
							Median	.00117													
							Total						17951.37	90100		1.73	17916.00	1.73	101.29	58.53	
Mississippi R., St. Louis, Missouri April 21, 1961																					
							WTS	.000285	.015	.01765	17.34	1700	.0001614	2796.39			.16	2639.08			
							FS	.00028	.295	.0975	6.94	1130	.000325	51394.80				20726.16			
							MS	.00128	.27	.126	2.12	102	.0000911	6217.16				6996.32			
							CS	.00232	.25	.255	1.16	24.3	.0001287	785.14				741.06			
							WCS	.00444	.075	.385	.76	13.3	.0000061	37.31				34.26			
							Median	.00128													
							Total						94213.65	66000		1.43	91361.06	1.39	58.65	66.29	
Mississippi R., St. Louis, Missouri July 16, 1953																					
							WTS	.000285	.01	.0217	16.04	6300	.0000007	2999.46			.15	2778.29			
							FS	.00028	.26	.0716	3.21	330	.000406	17906.10				6233.00			
							MS	.00128	.12	.1596	1.95	61	.0000077	646.91				641.33			
							CS	.00232	.17	.2640	.96	17.2	.0000007	158.01				162.82			
							WCS	.00444	.09	.385	.64	11.6	0	.00				.00			
							Median	.000787													
							Total						22581.68	26600		.64	20616.99	.67	15.15	22.92	
Mississippi R., St. Louis, Missouri April 19, 1954																					
							WTS	.000285	.01	.01725	12.63	10200	.0001002	6178.35			.12	6021.21			
							FS	.00028	.26	.0645	3.77	540	.0001318	1903.79				21047.46			
							MS	.00128	.13	.145	1.48	32	.0002014	899.25				911.15			
							CS	.00232	.06	.2375	.94	17.2	.0000063	23.38				26.83			
							WCS	.00444	.02	.385	.63	11.6	0	.00				.00			
							Median	.000787													
							Total						26185.28	27200		.89	25909.06	.90	16.29	16.46	
Mississippi R., St. Louis, Missouri August 27, 1950																					
							WTS	.000285	.04	.0261	9.08	6000	.0000004	1129.36			.11	13766.71			
							FS	.00028	.13	.0762	3.12	310	.0000030	1882.06				2306.17			
							MS	.00128	.16	.1580	1.56	40	.0000030	561.17				645.03			
							CS	.00232	.12	.2632	.90	16.2	.0000023	69.61				85.07			
							WCS	.00444	.1	.385	.63	11.6	0	.00				.00			
							Median	.00154													
							Total						13772.19	10200		1.35	14031.70	1.45	10.06	6.50	

TABLE NO. C-3

MODIFIED LAUREN METHOD
SEDIMENT LOAD CALCULATIONS

Location Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Ratio Comp/ft	Fr	Adjusted Computed Lead Time/Day	Adjusted Ratio Comp/ft	Adjusted Computed Lead Time/Day/ft	22						
																							Bed Composition	c	Bed-Material Tons Per Day		Adjusted Computed Lead Time/Day	Adjusted Computed Lead Time/Day/ft
																									Size Class	ft.		
Mississippi R., St. Louis, Missouri April 6, 1929																												

**MODIFIED LAMBERT METHOD
CALCULATING LOW CARBOHYDRATE
DIETARY FIBER**

C7

TABLE NO. C-7
MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Rio Grande near Bernalillo, New Mexico, Section 6-2 May 27, 1928																						
Rio Grande near Bernalillo, New Mexico, Section 6-2 June 16, 1928																						
Rio Grande near Bernalillo, New Mexico, Section 6-2 May 3, 1961																						
Rio Grande near Bernalillo, New Mexico, Section 6-2 June 21, 1960																						
Rio Grande near Bernalillo, New Mexico, Section 6-2 May 24, 1960																						

TABLE NO. C-3

[illegible]

TABLE 10, C-4

MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location Date	0	1	2	3	4	5	6	7	8	9	Bed Composition		10	11	12	13	14	15	16	17	18	19	Adjusted Ratio Comp/Fbs	Adjusted Load Tons/Day/Ft																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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SENDING TWO COPY LETTERS
RESENTING LONG CALCULATIONS
ON 13 FEBRUARY 1981 2100Z

Appendix C Modified Laursen Method Sediment Load Calculations

TABLE III, C-12

Location and Date	Q	V	W	S	TBF	Bed Composition			Bed-Material										
						Size			F	I	V'	C	Tons Per Buyoff	Bediment Load	Ratio Comp/Beds	Frauds Number Fr	Adjusted Completed Ratio Load	Adjusted Ratio Tons/Buyoff	
						Close	Open	St. ft.											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arkansas R. near Bardonia, Ark., Camp 7																			
Sta. 500, June 28, 1957	95.38	6.43	20.6	--	.000172	76	WFS	.000285	.033	.023	14.46	13100	.0215700	55.81			.10	62.35	
							FS	.000528	.134	.075	4.30	690	.0045281	16.01				12.82	
							MS	.001158	.57	.157	2.15	105	.0032915	8.48				6.47	
							CS	.00232	0	.262	1.79	29	0	.00				.00	
							WCS	.004644	0	.385	.00	15.7	0	.00				.00	
							Median	.001213											
							Total							81.10	62.49	1.91		61.83	1.46
Arkansas R. near Bardonia, Ark., Camp 7																			
Sta. 600, June 28, 1957	113.49	5.23	21.7	--	.000172	76	WFS	.000285	.033	.023	15.46	10000	.0275846	64.40			.20	59.46	
							FS	.000528	.134	.075	4.42	900	.0045281	26.40				16.31	
							MS	.001158	.57	.157	2.21	112	.0044296	13.57				9.49	
							CS	.00232	0	.262	1.32	31	0	.00				.00	
							WCS	.004644	0	.385	.90	16.1	0	.00				.00	
							Median	.001213											
							Total							124.53	97.17	1.20		87.06	.90
Arkansas R. near Bardonia, Ark., Camp 7																			
Sta. 900, June 28, 1957	153.72	6.1	25.2	--	.000172	76	WFS	.000285	.033	.023	16.73	12000	.0334353	120.77			.21	90.32	
							FS	.000528	.134	.075	4.90	540	.0054537	22.44				14.72	
							MS	.001158	.57	.157	2.30	140	.0040461	25.10				14.39	
							CS	.00232	0	.262	1.43	37	0	.00				.00	
							WCS	.004644	0	.385	.77	10	0	.00				.00	
							Median	.001213											
							Total							186.20	154.63	1.21		121.44	.79
Arkansas R. near Bardonia, Ark., Camp 7																			
Sta. 1300, June 28, 1957	146.16	6.71	22.2	--	.000172	76	WFS	.000285	.033	.023	15.24	10300	.0433034	102.53			.25	102.93	
							FS	.000528	.134	.075	6.67	1000	.0141124	57.57				32.49	
							MS	.001158	.57	.157	2.73	120	.0077097	31.33				17.67	
							CS	.00232	0	.262	1.34	32	0	.00				.00	
							WCS	.004644	0	.385	.91	14.3	0	.00				.00	
							Median	.001213											
							Total							271.83	146.63	1.94		153.20	1.49
Arkansas R. near Bardonia, Ark., Camp 7																			
Sta. 1500, June 28, 1957	118.00	5.49	21.5	--	.000172	76	WFS	.000285	.033	.023	15.06	13700	.0324007	94.30			.21	64.22	
							FS	.000528	.134	.075	6.46	750	.0049216	36.63				79.01	
							MS	.001158	.57	.157	2.70	112	.0040905	15.59				.00	
							CS	.00232	0	.262	1.32	31	0	.00				.00	
							WCS	.004644	0	.385	.90	14.2	0	.00				.00	
							Median	.001213											
							Total							141.99	103.21	1.20		84.72	.81

TABLE NO. C-13
MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location and date	Q cfs/ft	V ft/s	D ft	S ft	TSS %	Bed Composition		n	S	V'	C	Bed Material		Fr	Adjusted Computed Sediment Load Tons/Day/Ft	Adjusted Sediment Load Tons/Day
						Size Class	Dist. from Face, ft.					S	C			
Aransas R. near Bardonia, Ar., Range 10 Sta. 300, July 1, 1957	160.38	6.33	26.40	--	.000172	WS	0	.000205	.035	.074	15.98	15180	.032305	107.24	.22	94.97
						FS	0	.000205	.126	.077	4.98	1180	.011447	22.83		22.26
						MS	0	.001150	.37	.16	2.40	144	.0042540	21.34		18.28
						CS	0	.00232	0	.204	1.43	37.3	0	.00		.00
						WCS	0	.00444	0	.385	1.00	19	0	.00		.00
						Median		.001213								
						Total						227.41	201.53	1.13	144.81	.73
Aransas R. near Bardonia, Ar., Range 10 Sta. 700, July 1, 1957	89.96	5.23	17.20	--	.000172	WS	0	.000205	.035	.074	12.85	10400	.079925	70.47	.22	94.48
						FS	0	.000205	.126	.077	4.91	640	.002095	20.13		12.47
						MS	0	.001150	.37	.16	1.93	76	.001957	10.19		4.41
						CS	0	.00232	0	.204	1.17	24.3	0	.00		.00
						WCS	0	.00444	0	.385	.00	14	0	.00		.00
						Median		.001213								
						Total						106.99	119.83	.85	63.36	.53
Aransas R. near Bardonia, Ar., Range 10 Sta. 1100, July 1, 1957	51.15	4.78	10.70	--	.000172	WS	0	.000205	.035	.074	10.14	6300	.079925	41.41	.26	22.81
						FS	0	.000205	.126	.077	3.16	32.5	.004379	.96		.53
						MS	0	.001150	.37	.16	1.52	42	.003933	5.43		2.99
						CS	0	.00232	0	.204	.92	14.3	0	.00		.00
						WCS	0	.00444	0	.385	.63	11.5	0	.00		.00
						Median		.001213								
						Total						47.00	50.49	.82	26.33	.45
Aransas R. near Bardonia, Ar., Range 10 Sta. 1700, July 1, 1957	57.20	4.40	13.00	--	.000172	WS	0	.000205	.035	.074	11.17	7000	.072940	32.90	.22	23.33
						FS	0	.000205	.126	.077	3.40	425	.005415	6.71		5.45
						MS	0	.001150	.37	.16	1.48	53	.003929	4.47		3.83
						CS	0	.00232	0	.204	1.02	20	0	.00		.00
						WCS	0	.00444	0	.385	.76	12.5	0	.00		.00
						Median		.001213								
						Total						49.36	57.27	1.32	32.00	.84
Aransas R. near Bardonia, Ar., Range 10 Sta. 2700, July 1, 1957	31.56	3.92	8.00	--	.000172	WS	0	.000205	.035	.074	6.77	4550	.072772	16.06	.24	16.00
						FS	0	.000205	.126	.077	2.73	215	.004435	3.95		2.20
						MS	0	.001150	.37	.16	1.31	30	.003773	2.35		.00
						CS	0	.00232	0	.204	.80	14.1	0	.00		.00
						WCS	0	.00444	0	.385	.53	10.5	0	.00		.00
						Median		.001213								
						Total						25.16	16.61	1.52	13.10	.79

TABLE NO. C-14

MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

SEMI-LOG CALCULATION

Location and date	Q cfs/ft	V ft/s	D ft	S ft/ft	U ₁₀ ft/s	Bed Composition		n	I	Y	C	Bed Material		Fr	Adjusted Capacity Ratio Load Comp/ft ³				
						Size Class	Rate ft ³ /ft					Cap/ft ³	Observed						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Aransas R. near Bardonia, Ar., Range 14																			
Sta. 240, July 2, 1957	273.29	7.00	38.40	--	.000172	00	WFS	.000205	.033	.0241	19.17	20000	.0307716	227.40			.20	138.42	
							FS	.000205	.136	.070	3.92	1000	.0125045	92.44				65.90	
							MS	.001150	.37	.16	2.09	220	.0070245	57.71				30.82	
							CS	.00232	0	.264	1.75	39	0	.00				.00	
							WCS	.00444	0	.305	1.20	22	0	.00				.00	
							Median	.001213						377.43	301.22	1.23		204.34	.16
							Total												
Aransas R. near Bardonia, Ar., Range 14																			
Sta. 440, July 2, 1957	250.34	7.56	31.00	--	.000172	00	WFS	.000205	.033	.0241	17.10	15300	.0571402	256.94			.20	129.40	
							FS	.000205	.136	.070	3.31	1000	.0150400	98.72				58.12	
							MS	.001150	.37	.16	2.39	100	.0000030	57.40				33.94	
							CS	.00232	0	.264	1.57	45	0	.00				.00	
							WCS	.00444	0	.305	1.00	21.7	0	.00				.00	
							Median	.001213						392.14	277.19	1.42		231.45	.45
							Total												
Aransas R. near Bardonia, Ar., Range 14																			
Sta. 640, July 2, 1957	112.53	5.49	20.50	--	.000172	00	WFS	.000205	.033	.0241	12.97	11900	.0322343	65.77			.20	55.93	
							FS	.000205	.136	.070	4.32	800	.0033061	25.92				14.90	
							MS	.001150	.37	.16	2.10	90	.0004097	14.06				9.13	
							CS	.00232	0	.264	1.20	29	0	.00				.00	
							WCS	.00444	0	.305	.87	15.3	0	.00				.00	
							Median	.001213						125.49	90.42	1.39		81.90	.90
							Total												
Aransas R. near Bardonia, Ar., Range 14																			
Sta. 840, July 2, 1957	77.60	3.00	20.00	--	.000172	00	WFS	.000205	.033	.0241	11.00	11700	.0137913	29.25			.15	23.81	
							FS	.000205	.136	.070	4.34	700	.0037975	6.23				7.30	
							MS	.001150	.37	.16	2.00	97	.0030005	4.30				3.79	
							CS	.00232	0	.264	1.26	20.5	0	.00				.00	
							WCS	.00444	0	.305	.66	15.2	0	.00				.00	
							Median	.001213						61.00	61.13	.48		36.89	.60
							Total												
Aransas R. near Bardonia, Ar., Range 14																			
Sta. 1240, July 2, 1957	34.62	3.01	11.50	--	.000172	00	WFS	.000205	.033	.0241	10.47	7000	.0112377	10.32			.16	9.10	
							FS	.000205	.136	.070	3.23	345	.0023200	2.19				1.89	
							MS	.001150	.37	.16	1.50	45	.0011291	1.00				.00	
							CS	.00232	0	.264	.96	17.8	0	.00				.00	
							WCS	.00444	0	.305	.44	11.9	0	.00				.00	
							Median	.001213						11.79	10.60	.74		10.99	.59
							Total												

MODIFIED LAMBERT METHOD SEDIMENT LOSS CALCULATIONS

Appendix C Modified Laursen Method Sediment Load Calculations

MODIFIED LAURENSEN METHOD
SEDIMENT LOAD CALCULATIONS

C17

SMALL BUSINESS

Year	Production	Consumption	Exports	Imports
1961	10.15	30.00	.30	7.00
1962	10.15	30.00	.30	7.00

TABLE NO. C-10

[illegible]

TABLE NO. C-19
MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location and date	Q cfs/ft	V ft/s	D ft	S ft/ft	TSP	Bed Composition			n	I	V _c	c	Bed-Subsided		Froude Number Fr	Adjusted Computed Load Tons/Day/ft	Adjusted Bedrock Load Tons/Day/ft
						Size Com. Near Class Size, ft.							Computed	Observed			
						SS	FS	WFS									
Aransas B. near Hurrilton, Ar., Range 5																	
Sta. 546, April 5, 1958	41.63	3.31	13.00	--	.000166				.03	.010	14.44	12000	.014309	22.83		.16	19.15
						SS	FS	WFS	.000205	.2185	.041	4.32	.000177	34.48			6.79
						FS	FS	WFS	.00128	.0945	.102	1.06	.001654	1.96			1.44
						CS	CS	WCS	.00222	.0	.252	1.05	.0	.00			.00
						WCS	WCS	WCS	.00444	.0	.305	.69	12.3	.00			.00
						Median			.001213								
						Total							35.37	99.45	.71	29.57	.60
Aransas B. near Hurrilton, Ar., Range 5																	
Sta. 619, April 5, 1958	86.19	4.74	20.00	--	.000166				.03	.010	16.31	19000	.023196	26.77		.16	44.29
						SS	FS	WFS	.000205	.2185	.041	5.46	.010309	34.17			26.23
						FS	FS	WFS	.00128	.0945	.102	2.35	.0001794	5.09			4.89
						CS	CS	WCS	.00222	.0	.262	1.27	.0	.00			.00
						WCS	WCS	WCS	.00444	.0	.305	.87	12.6	.00			.00
						Median			.001213								
						Total							95.83	142.34	.67	79.45	.56
Aransas B. near Hurrilton, Ar., Range 5																	
Sta. 1116, April 5, 1958	71.92	3.83	19.30	--	.000166				.03	.010	17.83	17000	.019277	29.57		.15	24.77
						SS	FS	WFS	.000205	.2185	.041	5.26	.010309	22.42			26.23
						FS	FS	WFS	.00128	.0945	.102	2.36	.0017096	3.85			3.38
						CS	CS	WCS	.00222	.0	.262	1.23	.0	.00			.00
						WCS	WCS	WCS	.00444	.0	.305	.83	14.6	.00			.00
						Median			.001213								
						Total							66.44	92.64	.72	58.38	.63
Aransas B. near Hurrilton, Ar., Range 5																	
Sta. 1300, April 5, 1958	49.40	3.56	13.00	--	.000166				.03	.010	15.00	16000	.022825	26.42		.17	24.09
						SS	FS	WFS	.000205	.2185	.041	4.95	.010309	14.45			11.40
						FS	FS	WFS	.00128	.0945	.102	1.91	.0017253	2.38			1.85
						CS	CS	WCS	.00222	.0	.252	1.00	.0	.00			.00
						WCS	WCS	WCS	.00444	.0	.305	.71	12.6	.00			.00
						Median			.001213								
						Total							66.76	18.85	2.39	32.53	3.00
Aransas B. near Hurrilton, Ar., Range 5																	
Sta. 1700, April 5, 1958	27.58	3.17	8.70	--	.000166				.03	.010	11.97	9000	.022524	16.77		.19	12.20
						SS	FS	WFS	.000205	.2185	.041	3.53	.0004479	6.38			4.29
						FS	FS	WFS	.00128	.0945	.102	1.32	.0209706	1.06			.00
						CS	CS	WCS	.00222	.0	.252	.86	.0	.00			.00
						WCS	WCS	WCS	.00444	.0	.305	.56	10.6	.00			.00
						Median			.001213								
						Total							29.15	13.74	1.76	16.78	1.72

MODIFIED LAURENSEN METHOD

C21

TABLE no. C-21
MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location and date	Q	V	D	S	TSP	Bed Composition			V'	C	Bed-Material		Frodo Number Fr	Ratio Comp/Rbs	Adjusted Computed Ratio Load Comp/Rbs	Adjusted Ratio Comp/Rbs			
						Size					Bed-Material Load Ton Per Day/Ft	Ratio Comp/Rbs							
						mm.	Mean	ft.											
	Class	Size, ft.	P _b																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arkansas R. near Harrison, Ark., Range II																			
Sta. 376, April 7, 1958	56.42	3.42	14.06	--	.000164	95	W'S	.000205	.03	.010	15.42	16400	.0191320	26.15			.16	22.37	
							FS	.000205	.2105	.041	4.41	989	.0071031	13.32				11.20	
							MS	.001156	.0945	.142	1.90	82	.0017099	2.79				2.66	
							CS	.00232	0	.232	1.12	22.5	0	.00				.00	
							WCS	.00444	0	.305	.73	12.9	0	.00				.00	
							Median	.001213											
							Total							01.05	51.04	.02		56.10	.71
Arkansas R. near Harrison, Ark., Range II																			
Sta. 440, April 7, 1958	65.54	4.32	19.06	--	.000164	55	W'S	.000205	.03	.010	10.46	10290	.0231021	26.07			.17	66.79	
							FS	.000205	.2105	.041	5.33	1000	.0192040	34.77				27.72	
							MS	.001156	.0945	.142	2.79	127	.0026174	6.04				4.02	
							CS	.00232	0	.262	1.79	27.5	0	.00				.00	
							WCS	.00444	0	.305	.69	14.9	0	.00				.00	
							Median	.001213											
							Total							90.00	89.20	1.11		70.04	.08
Arkansas R. near Harrison, Ark., Range II																			
Sta. 970, April 7, 1958	79.28	3.03	20.70	--	.000164	55	W'S	.000205	.03	.010	10.47	10000	.0192040	60.73			.15	36.94	
							FS	.000205	.2105	.041	5.45	1000	.0192041	24.42				22.31	
							MS	.001156	.0945	.142	2.34	125	.0019071	4.00				2.79	
							CS	.00232	0	.262	1.77	28.5	0	.00				.00	
							WCS	.00444	0	.305	.66	15.1	0	.00				.00	
							Median	.001213											
							Total							69.43	66.27	.08		63.97	.73
Arkansas R. near Harrison, Ark., Range II																			
Sta. 1270, April 7, 1958	54.09	3.25	15.06	--	.000164	55	W'S	.000205	.03	.010	16.16	15290	.0192040	70.20			.16	25.43	
							FS	.000205	.2105	.041	6.76	1030	.0100041	13.27				13.13	
							MS	.001156	.0945	.142	2.05	94	.0013756	2.54				2.10	
							CS	.00232	0	.232	1.15	24	0	.00				.00	
							WCS	.00444	0	.305	.75	13.1	0	.00				.00	
							Median	.001213											
							Total							67.39	63.23	1.10		60.74	.94
Arkansas R. near Harrison, Ark., Range II																			
Sta. 1500, April 7, 1958	72.31	4.33	16.70	--	.000164	55	W'S	.000205	.03	.010	16.70	16300	.0231040	56.03			.19	61.87	
							FS	.000205	.2105	.041	4.96	1120	.0137190	30.49				22.61	
							MS	.001156	.0945	.142	2.10	99	.0026479	5.74				3.06	
							CS	.00232	0	.232	1.10	25	0	.00				.00	
							WCS	.00444	0	.305	.70	12.2	0	.00				.00	
							Median	.001213											
							Total							67.76	68.06	4.91		60.34	3.67

TABLE NO. C-22

MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location and date	cfs/ft	1	2	3	4	5	6	7	TW	Bed Composition										Bed Material Sediment Load Tons Per Day/Ft										Froude Number Fr	Adjusted Sediment Load Tons/Day/Ft				
										Size Class, %										Calculated															
										0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20					
Artesian R. near Merrillton, Ark., Range 24 Sta. 240, April 7, 1928 104.76 4.16 25.30 --		SS					.000166			.03	.010	20.42	21500	.0187100																					
		FS								.000208																									
		FS								.000208																									
		FS								.000208																									
		FS								.000208																									
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		FS								.000208																									
		FS								.000208																									
Artesian R. near Merrillton, Ark., Range 24 Sta. 241, April 7, 1928 104.15 4.25 17.00 --		SS					.000166			.03	.010	18.46	12000	.0187100																					
		FS								.000208																									
		FS								.000208																									
		FS								.000208																									
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		FS								.000208																									
		FS								.000208																									
Artesian R. near Merrillton, Ark., Range 24 Sta. 242, April 7, 1928 104.99 4.02 16.00 --		SS					.000166			.03	.010	16.44	11000	.0187100																					
		FS								.000208																									
		FS								.000208																									
		FS								.000208																									
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		FS								.000208																									
Artesian R. near Merrillton, Ark., Range 24 Sta. 243, April 7, 1928 105.20 5.05 16.00 --		SS					.000166			.03	.010	16.44	11000	.0187100																					
		FS								.000208																									
		FS								.000208																									
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		FS								.000208																									
		FS								.000208																									
Artesian R. near Merrillton, Ark., Range 24 Sta. 244, April 7, 1928 105.93 4.46 10.50 --		SS					.000166			.03	.010	12.15	11000	.0187100																					
		FS								.000208																									
		FS								.000208																									
		FS								.000208																									
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		FS								.000208																									

MODIFIED LAURSEN METHOD
 RESIDENT LOAD CALCULATIONS

Appendix C Modified Laursen Method Sediment Load Calculations

TABLE NR. C-21

MODIFIED LAURSEN METHOD
SEDIMENT LOAD CALCULATIONS

Location and Run No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Adjusted Lead Ton/Run/FT	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run	Adjusted Cap/Run
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VERIFIED ANSWER KEY

Appendix C Modified Laursen Method Sediment Load Calculations

TABLE III. C-74

[illegible]

MODIFIED LAURSEN METHOD SEDIMENT LOAD CALCULATIONS

150000

	1	2	3	4	5	TBF (Assumed)	Bed Composition			n	z	y'	Concentration c				Fr	Adjusted Comp/obs z	Adjusted Ratio Comp/obs z	Adjusted Lead Time/hr/ft
							Size Bene. Mean Class Size, ft.	Ph	c				Observed z	c	Observed z					
Flume Tests by Tech., .04oz Silt Run No. 101	—	1.87	.546	.00101	.65	Median	.000131	1	.0043	31.33	34000	19.36	8.34	2.32	.44	6.40	.79	180.51	230.34	
Flume Tests by Tech., .04oz Silt Run No. 102	—	1.74	.442	.00117	.65	Median	.000131	1	.0043	30.46	33000	21.00	8.2	2.67	.45	7.26	.89	157.39	177.90	
Flume Tests by Tech., .04oz Silt Run No. 103	—	1.91	.674	.00086	.65	Median	.000131	1	.0043	31.75	34000	15.51	5.04	2.66	.41	5.61	.96	195.10	202.99	
Flume Tests by Tech., .04oz Silt Run No. 104	—	2.13	.478	.00197	.65	Median	.000131	1	.0043	29.85	33000	32.26	9.7	3.33	.50	9.46	.95	208.95	246.65	
Flume Tests by Tech., .04oz Silt Run No. 105	—	2.61	.565	.00114	.65	Median	.000131	1	.0043	33.47	36000	41.99	8.34	5.04	.61	16.38	1.27	421.21	332.46	
Flume Tests by Tech., .04oz Silt Run No. 106	—	1.23	.542	.00081	.65	Median	.000131	1	.0043	27.44	29500	6.90	3.03	2.30	.29	3.41	1.12	61.36	54.34	
Flume Tests by Tech., .04oz Silt Run No. 107	—	.85	.30	.00078	.65	Median	.000131	1	.0043	22.71	24700	3.56	.73	4.87	.24	2.07	2.83	18.02	6.37	
Flume Tests by Tech., .04oz Silt Run No. 108	—	2.42	.643	.001	.65	Median	.000131	1	.0043	33.96	36000	28.08	9.01	2.06	.52	6.16	.83	332.76	424.07	
Flume Tests by Tech., .04oz Silt																				

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Edward B. Madden

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Consulting Engineer, 10109 McCree Road,
Dallas, TX 75238

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The sediment transport function developed by Emmett M. Laursen was adopted for the Arkansas River navigation project because it expresses transport rate using terms that permit separating the effects of hydraulic and sediment parameters. However, in attempting to reproduce measured data from the lower Arkansas River, the Laursen function gave results that were systematically low. The same trend appeared when the function was applied to Missouri River data. Therefore, Laursen's functional relationship

$$f\left(\frac{\sqrt{\tau_o/\rho}}{w}\right)$$

was replotted for the Arkansas River planning studies based on Arkansas River data. Subsequently, another graph of the relationship was developed using data from several other rivers. The work reported in this study is an effort
(Continued)

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Bed-material load Sediment transport
Froude number Streambed
Sediment load

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to collapse those functional relationships into a single graph. The approach was to introduce a correction coefficient based on Froude number.

The resulting relationship was tested using data from eight field sites and five flume studies. Results, with adjustments for Froude number effects, are satisfactory for sediment sizes ranging from 0.031 mm to 4 mm, flow depths from 0.25 to 54 ft, flow velocities from 0.85 to 7.7 fps, energy gradients from 0.00001 to 0.1 ft/ft, water temperatures from 36 to 90° F, and Froude numbers from 0.07 to 1.7 except when the grain tractive force is less than about two times the critical tractive force. Sediment transport is very small in this case, and there is probably a hiding effect beyond that included in Laursen's formulation.